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THE FIFTH COMMISSION OF THE R.R.S. *DISCOVERY II*

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Meeting of the Society, 3 March 1941

DURING the ten years preceding the outbreak of war the R.R.S. *Discovery II* has been almost continually at work in the Southern Ocean. On her first commission she sailed from England at the end of 1929, and the fifth commission was completed in May 1939. On each of these expeditions the ship generally sails from London in October and is away for twenty months, and the first four commissions, as well as the work of the *Willaim Scoresby* and the earlier work of the *Discovery*, have at various times formed the subject of papers read at meetings of this Society. I have now to give an account of the fifth commission, and am grateful to the Society for the opportunity to complete the series.

In normal times this paper would have been given by Mr. H. F. P. Herdman, who was in charge during the greater part of the voyage. Our staff however is now very much scattered, and he is engaged on Admiralty work which keeps him far from London.

Since the Discovery Committee's activities in the field were necessarily suspended at the outbreak of war it will perhaps be appropriate here to begin with a brief summary of the lines on which the work as a whole has been planned. In effect it is a marine biological survey of the Antarctic, and has special reference to whales, and their physical and biological environment, because whales are at present the most important of the economic resources of the Antarctic.

Fig. 1 shows roughly the routes followed by the *Discovery II* in her different voyages. It does not distinguish the different expeditions, and it is not even an accurate chart, for in many places the ship has steamed along the same route several times over, and here the tracks have been spread a little so that they can be distinguished from one another. Furthermore, there has been much intensive work in the neighbourhood of South Georgia and the South Shetland Islands, and many small deviations from the ship's course which cannot be shown. In spite of these defects the chart conveniently illustrates

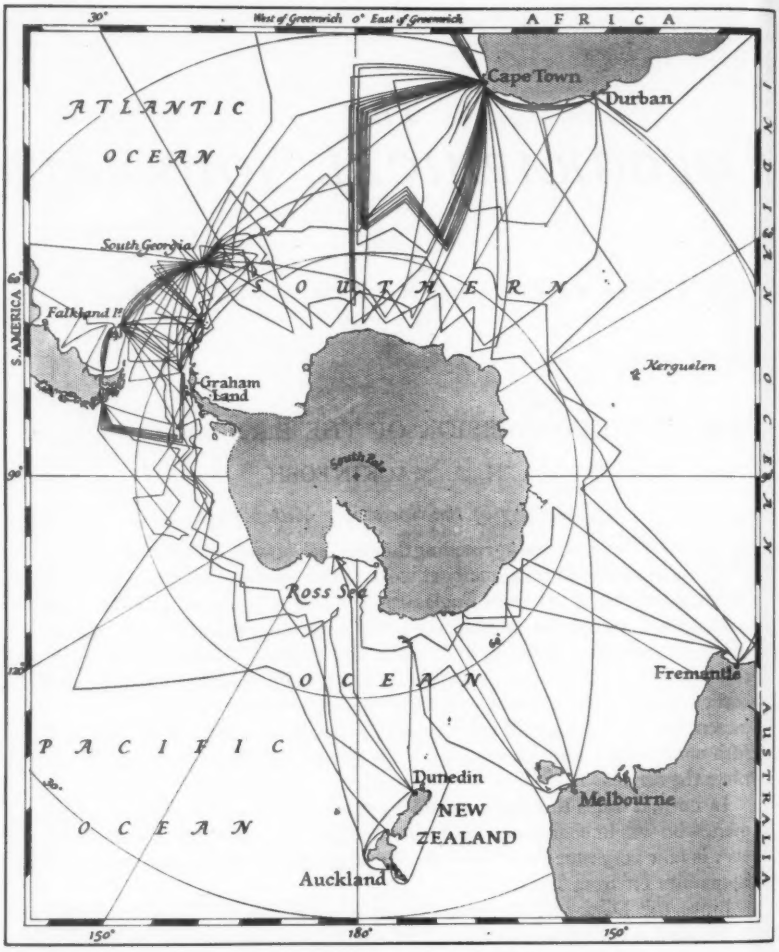


Fig. 1. Voyages of the "Discovery II," 1929–39

certain basic principles on which the survey is planned. The Southern Ocean forms a continuous belt of deep water, and except for certain disturbances we find little change in the physical conditions or in the flora and fauna if we move round it in an east or west direction. There are essential changes however in a north and south direction, and a series of meridional observations will disclose zones or gradients in almost all phenomena. The pack-ice, for example, occupies a zone in the southern part of this ocean, the sea temperature forms a gradient (though with certain irregularities), and different species of oceanic organisms, including the whales, tend to occupy different circumpolar zones. Clearly then, a line of observations running north and south will be far more instructive than one running east and west. Moreover

the main water movements are in an easterly direction, and a current is best studied by transverse observations. It is for this reason that so many of the ship's longer passages are distributed in a north and south direction in various parts of the ocean.

Whales largely occupy a zone lying immediately north of the pack-ice, and observations have been concentrated here by means of zig-zag movements which in Fig. 1 are best seen near the Antarctic Continent to the south of South Africa and Australia, and in the Pacific sector.

Next to the latitude the most important cause of variation is the season. Apart from alterations of temperature, vast changes take place at different times of year in the distribution of ice, in the abundance and distribution of plankton, and in the distribution of whales. These variations are best studied by observations repeated at different times of year on the same meridian or within any important area. This has been done on the Greenwich meridian, where conditions are fairly typical of the whole Southern Ocean, in 20° E., in 80° W., on the whaling grounds around South Georgia (where a series of intensive surveys have been made), and in the Scotia Sea, where conditions are rather specialized.

Of course the pattern is not so evenly and precisely distributed as we should like it to be. Enormous distances have to be covered and fuel is a limiting factor. Stoppages required for routine scientific work limit the ship's cruising range to little more than 5000 miles, and hence many lines of observations during circumpolar cruises must be oblique instead of meridional. The track chart is also complicated by various routes undertaken for special purposes, such as surveying or the investigation of specific local problems.

Broadly speaking however the principal observations are on meridional lines for the study of water movements, zones, and gradients; on zigzag tracks for more concentrated investigation of a particular zone; on selected lines or in selected areas repeated several times for the study of seasonal variations; and in certain areas where special conditions call for intensive examination.

The ship's track during the fifth commission is shown in Fig. 2. On this occasion there were two big items on the programme which left little time for any supplementary work. First there was to be a circumpolar voyage, and then a long series of repeated observations on the Greenwich meridian and 20° E. A circumpolar voyage had been carried out in 1932 during the second commission when Mr. D. D. John was in charge. This was in the winter months, and a similar cruise in the summer months had been planned for the fourth commission under Dr. G. E. R. Deacon. The relief of Mr. Ellesworth and Mr. Hollick-Kenyon in 1936 had necessitated alterations in the programme, and the circumpolar voyage was postponed until the fifth commission.

The *Discovery II* sailed as usual from London in October 1937, and after refuelling at St. Vincent, proceeded straight to Cape Town. The scientific Staff included Mr. Herdman, Mr. Clowes, Dr. Hart, and Mr. Nicholson, and Lieut. L. C. Hill, O.B.E., R.N.R., was again in executive command. We did not attempt much scientific work on the outward voyage apart from routine hauls with large tow-nets in deep water. These hauls produce a great variety

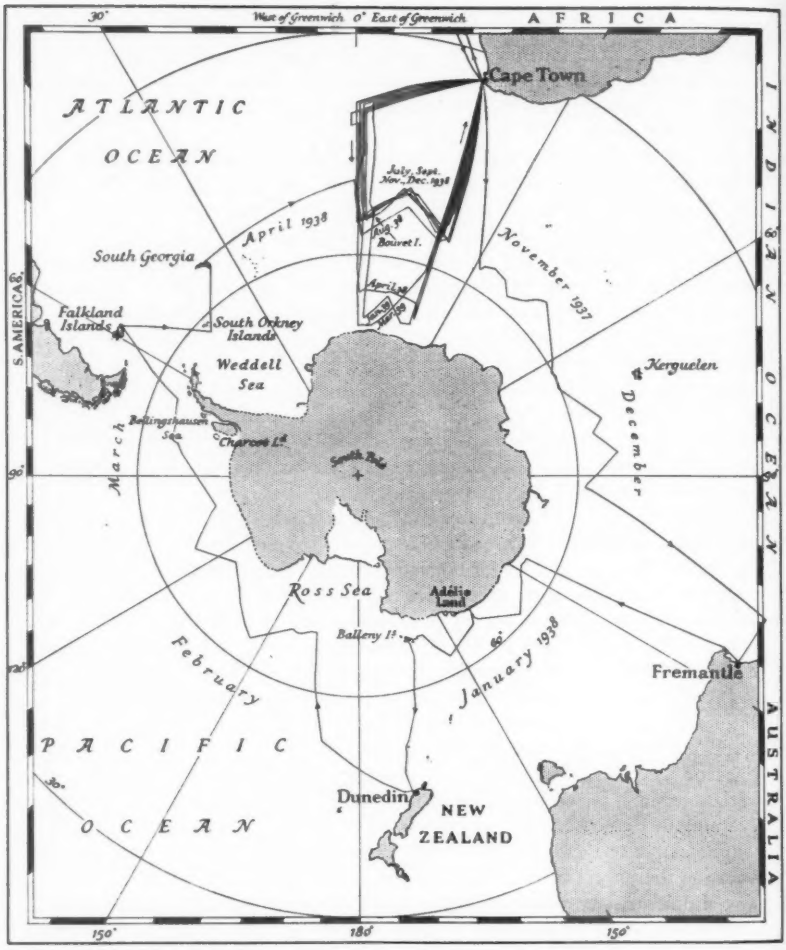


Fig. 2. The fifth commission, 1937–39

of interesting organisms, and there are many other things to interest the biologist in such a voyage through the tropics. Among the more interesting phenomena we saw were schools of Sperm whales and a fine display of luminescence by the gregarious organism, *Pyrosoma*, which Professor Hardy mentioned in his account to the Society of our first work at sea in the old *Discovery*. We saw it one night quite near the equator, where it formed acres of cold white phosphorescence which, in the darkness, bore an uncanny resemblance to streams of pack-ice.

We reached Cape Town on November 7, and having taken stores and fuel, sailed a few days later on the first long lap of the circumpolar voyage. This passage through the sector of the Antarctic which lies to the south of the

Indian Ocean is a very long one. No fuel could be obtained until we reached Fremantle, and the route taken represents about the limit of the ship's cruising range. It should be remembered that a regular routine of observations is carried out during almost the whole time the ship is at sea. The observations are made mostly at full stations (generally once a day) where the ship is stopped for three or four hours. Temperatures are determined and chemical estimations made at many depths from the surface to the bottom, and hauls are made at various levels for studying the distribution of the minute vegetable matter, the crustaceans on which the whales feed, and other forms of plankton. In Antarctic waters a constant look-out is kept for whales. Thus all the tracks shown in Fig. 2 are lines along which a great variety of observations are constantly being made.

The ship steamed on a south-south-easterly course from Cape Town to the edge of the pack-ice. These passages through the open expanses of the Southern Ocean are seldom very agreeable. The weather is generally abominable, especially between 50° and 60° S., and the work is a monotonous routine. Off the ice-edge however better conditions are to be expected, and the appearance of whales and ice provide plenty to arouse the interest of all on board. On this occasion we were troubled with the usual westerly gales on the southward voyage, and, in the higher latitudes, were delayed by snow and fog. On November 23 the fog cleared suddenly in the morning, Antarctic and snow petrels appeared, both of which indicate the proximity of the ice, and the same evening the pack came in sight. We now turned east, making frequent net hauls to study the distribution of the whales' food or "krill," and began a series of tacks to the north-east and south-east in order to cover as much as possible of the zone in which the majority of whales are to be found. This was continued for a fortnight to a point nearly 2000 miles east of the position at which we first met the ice, and left us with no more than the necessary margin of fuel to reach port. We turned north and proceeded to Fremantle, and this time we were fortunate in having fine, calm weather all the way, which enabled us to make an excellent line of stations. We spent Christmas at Fremantle and started the next section of the voyage on December 29.

I should mention that before this commission began the subject of polar research had been considered at the Imperial Conference in 1937, and the possibility of co-operation between the southern dominions was raised. It is not necessary to enter into this matter in detail since any such project was naturally suspended in war time. It was suggested however that the governments interested should appoint one or two scientific or other workers to sail for a time in the *Discovery II*, rather in the capacity of observers who would become familiar with our methods of work. This was arranged, and Mr. A. W. Cornish, who was a meteorologist of the Australian Central Bureau, joined the ship at Fremantle.

We sailed due south from Fremantle, and this cruise was perhaps the most interesting in the whole commission. The passage to the ice was delayed by head winds but was otherwise uneventful, and on January 11 we turned north-east on the usual zigzag route. The weather was now very fine and calm, and Mr. Cornish was able to make observations on wind currents by means of

balloons. This involves the use of a theodolite and is therefore a difficult operation on the deck of a small ship at sea. The theodolite however was set up in gimbals, and the experiments were carried out quite successfully.

After turning south-east again we were surprised to find that the pack had cleared away from the coast of the continent, and in the morning of January 16, between 139° and 140° E., the ice slopes of Adélie Land came in sight. Huge crevasses and ice-cliffs could be plainly seen, but our exact position and distance from the coast were very uncertain. With overcast weather we had had no sights for some time, and the proximity of the magnetic pole made the compasses almost useless. As we approached the land we met with an easterly wind which soon increased to gale force. Driving snow came on, the sea became infested with growlers, the coast was lost to sight, and for some time we could only set our course by the wind. This wind was no doubt a sample of the incessant easterly gales which were experienced by the Austra-

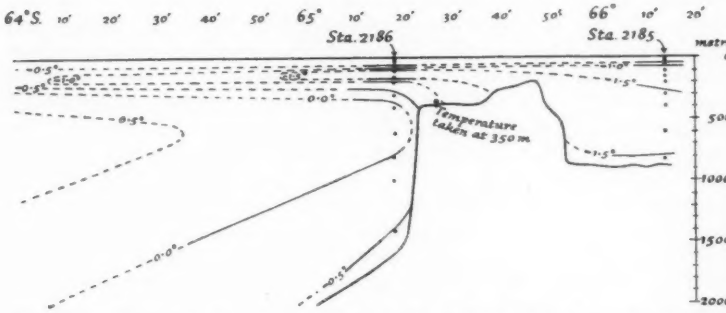
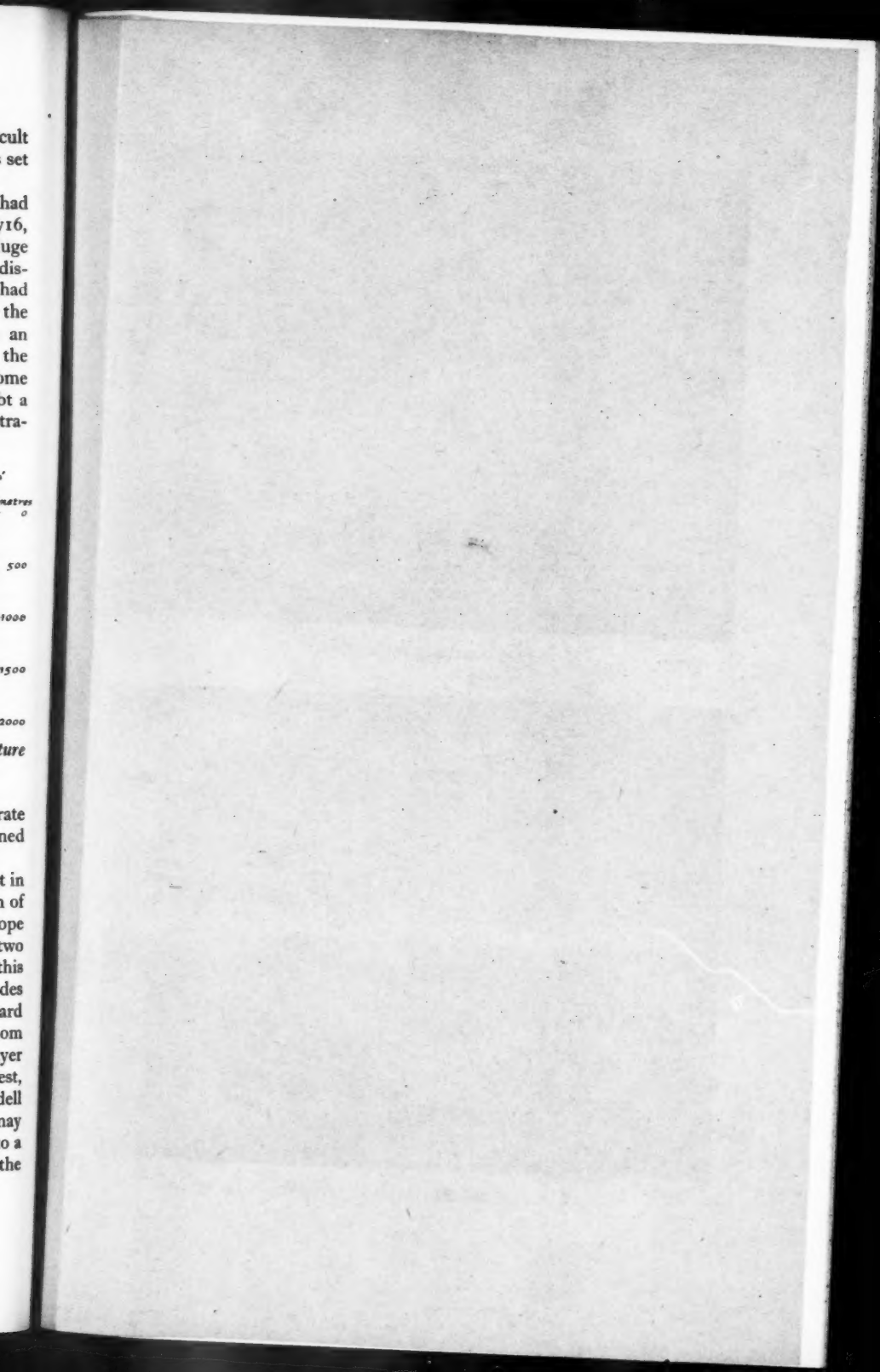


Fig. 3. Isotherms at edge of continental shelf off Adélie Land from temperature profiles at stations 2185 and 2186

lasian Antarctic Expedition of 1911–14. The wind appears however to operate only in a very limited coastal zone, for on turning north again we regained calm conditions after a few hours' steaming.

There was little time to spare, and in these conditions there was no point in attempting a landing. However we were able to make a useful comparison of the arrangement of the water layers here at the edge of the continental slope with the conditions in the Ross Sea which were described by Dr. Deacon two years ago in his account of the fourth commission of the *Discovery II*. In this paper (*Geogr. J.*, 93, pp. 186, 192) he explained that in the higher latitudes of the Southern Ocean a layer of "warm deep water" moves southward between the cold Antarctic surface water and the cold Antarctic bottom water, both of which move northward. The fate of this intermediate layer when it approaches the continental slope is a point of considerable interest, and hitherto we had no information on it except in the Ross and Weddell seas. Fig. 3, which is a vertical section of the temperature distribution, may be compared with Deacon's Fig. 4. It shows the continental slope rising to a ridge, on the south (right hand) side of which is a basin lying between the



Iceberg with sea freezing

Bergs off the Barrier at daybreak, lat. 70° S. long. 0°

Clouds over Young Island, Balleny Islands

Buckle Island, Balleny Islands

ridge and the continental coast. It is seen that as in the Ross and Weddell seas the warm deep water in this more typical part of the coastal region comes close to the edge of the slope, but does not penetrate to the basin beyond it. Such observations have a bearing on the origin of the Antarctic bottom water and on the distribution of the krill which appears to pass the early stages of its life cycle in the warm deep water.

Constant echo soundings were taken at this time, and it was interesting to note that the ridge was marked by a number of the usual tabular icebergs which were almost certainly grounded on it. The ship passed close to one which had in general a fresh, new appearance, with clearly cut vertical cliffs. The height was found by sextant to be 126 feet, and the echo soundings showed a very regular flat bottom at 104 fathoms. The maximum depth of the berg below water should therefore be 624 feet or 4·9 times the height above water.

Having completed our observations on the shelf we continued on the next north-east tack, and after two days turned to the south-east again. Here we met with one of those exceptionally large icebergs which are generally called ice islands. This one was of irregular shape and probably about 10 miles across. Considerably bigger ones have been reported in the Weddell sector, but I do not know that such large ones have been seen in other parts of the Antarctic. The weather was calm and clear, the spouts of many whales could be seen, often at great distances, and the cliffs of the ice island made an unusually impressive spectacle against a fine sunset.

Next day, January 20, we reached the pack-ice about 100 miles west of the Balleny Islands. We skirted it eastwards and came up to Young Island, the most northerly of the group, the following morning. Here was an opportunity for Captain Hill to add a little to the very brief survey he had made in 1936 during the ship's fourth commission. Weather conditions were now more favourable and we were able to spend two days in a running survey with constant sun sights, steaming closely round all except Sturge Island. The latter was cut off by pack-ice of which the edge lay about half-way between it and Buckle Island. Young Island and Buckle Island are covered by ice sheets, rising in most places by moderate slopes to no very great height. Sturge Island seen at a distance is clearly higher than the others but did not seem to be much over 5000 feet. Dr. Deacon, in his paper referred to above, comments on some inaccuracies in the older charts, and we were now able to amplify the corrections made in 1936. The echo-sounding machines were in continuous use. There is deep water close to the islands, and the echo recorder revealed some remarkably steep submarine slopes. It is noteworthy that great numbers of Blue, Fin, and Humpback whales were concentrated in the neighbourhood of the islands, in greater abundance perhaps than any of us had seen before.

The sea was not quite calm enough for us to attempt a landing, and having done as much as we could without an altogether more ambitious surveying programme we left the islands and proceeded northwards to New Zealand. Campbell Island lay on our course, and on January 28 we anchored there in the south harbour while a collecting party went ashore. Campbell Island was at the time uninhabited, but many sheep were to be seen. It is a

nesting place for the wandering albatross and is covered, at least around this anchorage, by a very dense low scrub which made heavy going for the shore party.

We sailed again the same evening and reached Dunedin on January 31. At this point it was necessary for me to leave the ship and return home. Of the rest of the commission therefore I cannot speak at first hand, but with the help of the reports sent home by Mr. Herdman I hope to be able to give an adequate account of the activities which followed.

The *Discovery II* left Dunedin on February 8 to begin another very long section of the circumpolar voyage, this time through the Pacific sector. Here again the programme had to be adapted to the ship's bunker capacity, for no more fuel could be obtained until she reached Port Stanley, in the Falkland Islands. Mr. Cornish had also disembarked at Dunedin, and his place was taken by Mr. A. M. Rapson, of the Fisheries Branch of the Marine Department of New Zealand. After some sounding and dredging off the Antipodes Islands the ship turned almost due south on the meridian of 170° W., and reached the ice edge on February 18 in 68° 39′ S. Then began the usual north-east and south-east tacks based on the edge of the pack. There is not very much to be said of this part of the voyage. The pack-ice is comparatively stagnant in the Pacific sector, and no ship has been able to reach or even sight the continental coast between the Ross Sea and Charcot Land in the Bellingshausen Sea. The work was impeded by head winds and fogs, but some interesting observations were made on whales in spite of the generally bad visibility. The Pacific sector is the only part of the Antarctic which has not yet been worked by the whaling industry, and at the International Whaling Conference of 1938 it was agreed to close it as a whale sanctuary, in the first place for a period of two years. It was generally supposed that whales are scarce in this sector, but although they are probably less abundant than in some other regions, our observations on this occasion showed that in some parts there are very considerable numbers of them, and that if the sanctuary is maintained it will at least have the effect of protecting a fairly substantial part of the southern stock of whales.

Owing to the continual head winds the tacks off the ice edge had to be stretched a little towards the end of this cruise, and the ship reached Port Stanley in the Falkland Islands on March 15. Five days were spent here, and then the voyage was continued on a south-easterly course towards the South Orkney Islands. A glance at Fig. 1 will show that this was on and across well-beaten tracks. Additional observations however are always of value since they help us to ascertain the extent to which conditions vary from year to year. The ship did not call at the South Orkneys where a good deal of surveying had been done in previous commissions, but continued until she met the pack about 90 miles south of the islands. Course was then set for South Georgia, and she anchored there in Grytviken harbour on March 28. South Georgia has generally been our most important base in the Southern Ocean, and in previous commissions we have made frequent calls there. Fuel can be obtained at the whaling stations at Grytviken and Leith Harbour, there are facilities for minor repairs, and our shore laboratory at Grytviken, though no longer occupied by our own staff, was still useful for storage and for the pre-

paration of certain chemical standards which require more accurate weighing than is possible in a floating laboratory.

After a week here the *Discovery II* began the last section of the circumpolar voyage. Since the second part of the commission was to be spent in a series of observations repeated as many times as possible on the meridians of 0° and 20° E., it was arranged that the final part of the circumpolar cruise should include a preliminary set of observations on these meridians. The ship therefore steamed slightly north of east until she reached the Greenwich meridian in 50° S. and then turned south to the ice edge. In April the ice still lies well to the south, but it has begun its winter advance towards the north and young ice is generally forming. The ice was now found in 64° 52′ S. and new pancake ice was forming rapidly. The ship turned eastwards, skirting the ice edge as far as 20° E. and then turned north on the long run up to the Cape.

In previous commissions we have generally set aside a month in the summer for surveying work, generally in the Falkland Islands Dependencies, where there are many harbours and anchorages and where correction and improvement of the charts were much needed. There is still much to be done in this field, but in the fifth commission we could not sacrifice a month in the summer (for surveying needs the best weather conditions) without upsetting the general programme of work. It was desirable that the circumpolar voyage should be completed within the summer months, November to April, in order to obtain the full benefit of a comparison with the similar winter voyage of 1932, and we needed as long a period as possible to carry out an uninterrupted series of the repeated observations which were to occupy the second part of the commission. Surveying was therefore restricted to the short period spent at the Balleny Islands.

The whole of the ship's programme was planned in considerable detail before the *Discovery II* left London. With the experience of four previous commissions we were able to work out with some confidence the distances to be covered, and the time required for the different sections of the circumpolar cruise, and to make due allowance for bad weather and ice conditions; seven months after leaving London the ship reached the Cape, at the completion of the voyage, within four days of the scheduled date.

The *Discovery II* reached the Cape on 4 May 1938, and was now due for a refit. After a season's work in the south an overhaul is always necessary, and it has generally been found convenient to have this done at the naval dockyard at Simonstown. As usual two months were spent in port. This gives time for dry docking and a variety of repairs, the scientific staff are able to deal with arrears in routine laboratory work, and to make a preliminary examination of the results, and there is a period of recreation and change of scenery for all hands, which is a much needed break in the year and a half spent almost entirely at sea and out of sight of land.

The ship sailed again on July 1, and the work now before her was not quite like any programme we had undertaken previously, for it was simply to spend nine months sailing round the same course as often as possible, and making observations in exactly the same way each time—a monotonous and exacting task, only mitigated by slightly more frequent calls at a civilized port. The

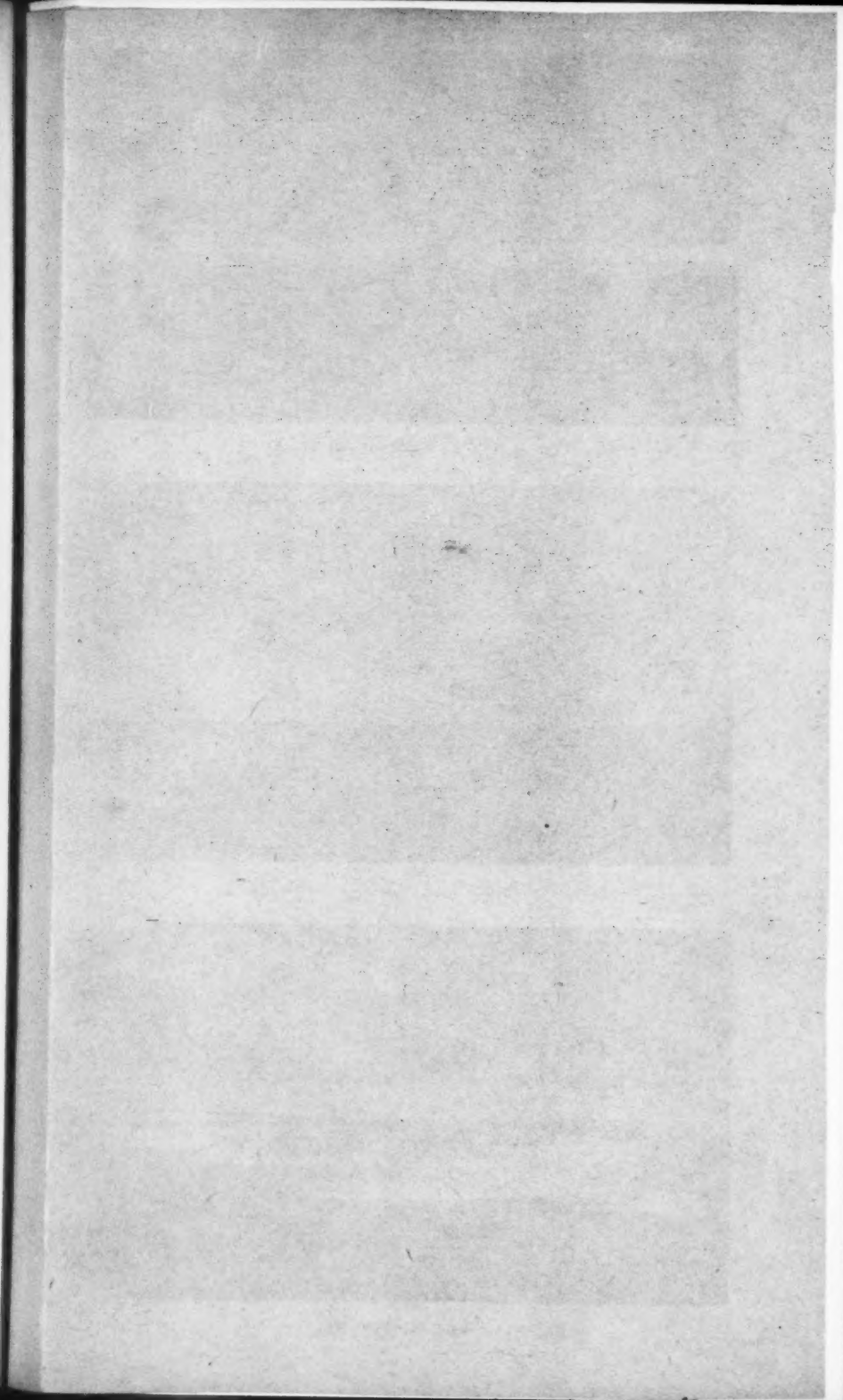
importance of the study of seasonal changes has been mentioned above. It is not merely a question of ascertaining the seasonal changes in the quantities of whales, the abundance of their food, the nutritive salts in the water, the sea temperature, the distribution of ice, and so on; it is also a means of co-ordinating and interpreting much of our past work. The voyages of the *Discovery II* have taken her to all parts of the Southern Ocean, and since we cannot run a fleet of ships, the observations have necessarily been made to a certain extent in different months in different places. A set of observations in one locality at one time of year cannot properly be compared with a set of observations in another locality at another time of year if we do not know how much to allow for seasonal variations. The repeated observations in 0° however provide a criterion which will go far to facilitate such comparisons.

It was planned to steam from Cape Town to a point about 40° S. close to the Greenwich meridian, to turn south as far as the edge of the pack-ice, then north-east and south-east to meet the ice again in about 20° E., and then to run almost due north to the Cape. The observations were to include the usual daily full station with physical and chemical records at all depths, net hauls at the surface and through deeper layers to 1000 or 1500 metres, a constant look-out for whales, systematic observations on meteorological conditions and oceanic birds, and extra net stations while in Antarctic waters. The only major difference between the different cruises would arise from the changing latitude of the pack-ice.

The first cruise, as was to be expected in the dead of winter, was carried out in shocking weather conditions. There was a fine interval during the southward run, but a whole gale was blowing when the ship met the pack-ice, and this continued for a week. No young ice was seen in 0°—it had probably been broken up by the heavy seas—but in 20° E. there were streams of new pancake ice. The weather conditions may be illustrated by a quotation from one of Mr. Herdman's reports in which, speaking of observations on whales, he says, ". . . in Antarctic waters either the wind force was so great or the visibility so low that during 95 per cent. of the hours of daylight it would have been impossible to have seen a 'blow' unless it occurred alongside the ship." There was little improvement in the weather until the ship was well on the way north. Cape Town was reached on July 28.

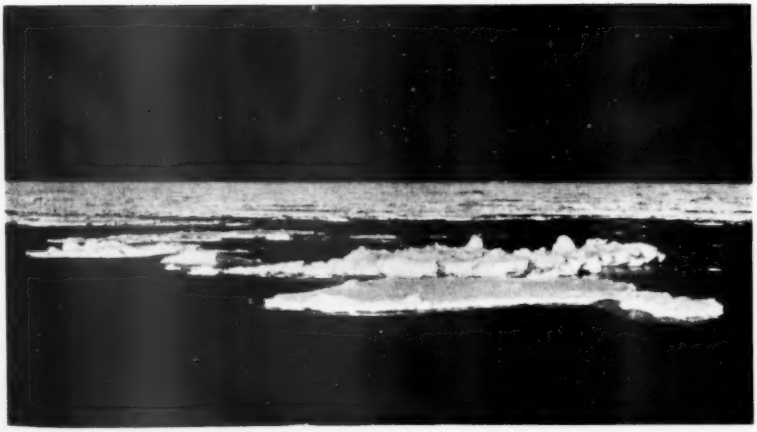
The second cruise, carried out in August, was very similar, and weather conditions were little better. Streams of sludge ice, the earliest stage in the freezing of the sea, were met with not far from the previous position of the ice, but the ship steamed through this and met with more solid pack 100 miles farther south.

The third, fourth, and fifth cruises (September 14 to December 19) covered very much the same range, the ice showing very little sign of its summer retreat to the south. After the second cruise however weather conditions were considerably better, though the inevitable gales were experienced from time to time. During the fourth cruise the Union Government was represented by Mr. R. R. Charter, of the Division of Fisheries of the Department of Commerce and Industries. There is little else to be said of the first five cruises. They were on the whole uneventful, but a solid body of valuable data had been collected. The sixth and seventh cruises, January to March 1939, which



Land in 69° 58′ S., 1° 31′ E.

Land in 70° 04′ S., 3° 49′ E.



The pack-ice edge

The Barrier in 70° 40′ S., 3° 94′ E.

Landing at Bouvet Island

concluded the series, were more interesting for the ice had now receded and allowed the ship to reach much higher latitudes.

The sixth began on January 6, and Mr. Englebrecht, of the Meteorological Office at Pretoria, and Mr. Ladell, of the University of Cape Town, joined the ship for this cruise. So that a new line of soundings could be established, the southward route was set a little to the east of the previous routes. This took the ship close to Bouvet Island, and a small party succeeded in making a landing, a feat which has rarely been accomplished.

Bouvet Island is a small island covered by a thick ice sheet and fringed in parts by high rocky cliffs and elsewhere by ice-cliffs. There is no sheltered anchorage and the only landing places are two or three small exposed beaches. In one sense it is perhaps the most isolated island in the world, for there is no other land of any sort within nearly 1000 miles of it in any direction. Mr. Herdman, in his report, says that on approaching the island "it was easily seen that a landing at either of the known landing places (*i.e.* at Cap Circoncision or on Lars Islet) would be out of the question on account of a moderate westerly swell and a W. × N. wind of force 4/5, so we steamed round to the lee side where we luckily found a small beach at the N.E. corner. The ship was anchored close-to, in 15 fathoms, and Mr. Englebrecht was landed successfully at 16.00 hrs. He made two sets of observations with pilot balloons." Cap Circoncision and Lars Islet appear to be the best landing places, but they are exposed to the prevailing winds and suitable conditions for a landing must be rare. The *Norvegia* expedition made several landings at these places, but it seems that they did so when the island was partly surrounded by pack-ice which would have the effect of damping down the swell. Bouvet Island lies somewhere near the mean northern limit of the pack and is likely to be surrounded by ice in the late winter and spring.

Between about 30° E. and 30° W. the ice-edge generally retreats very suddenly towards the end of December. It appears that the cold current flowing eastwards from the northern part of the Weddell Sea maintains a belt of ice in this region until the summer is well advanced, while a warmer current, whose origin is in the Indian Ocean, flows westwards in a higher latitude, and causes the central part of the ice-belt to melt and break up. In December whaling vessels can sometimes force their way through the outer belt of ice and emerge into comparatively clear water about 60° S. Fig. 4 shows this rapid break up of the ice in December in the Atlantic sector. The monthly ice limits shown here were derived from many records made both by the Discovery Committee's ships and by whaling vessels, but the observations made during the *Discovery II's* repeated cruises were specially helpful, particularly where they were outside the normal whaling season.

After calling at Bouvet Island the ship continued on her southward voyage. It was now late in January, the outer belt of ice had vanished, and she was able to proceed on this course for several hundred miles until she reached the beginning of the Antarctic continental slope, where she was stopped by pack in 69° 39′ S. She turned as usual to the north-east, back to the ice again in 20° E., and without any noteworthy incident steamed north again to Cape Town. This sixth cruise was remarkable for exceptionally fine weather which

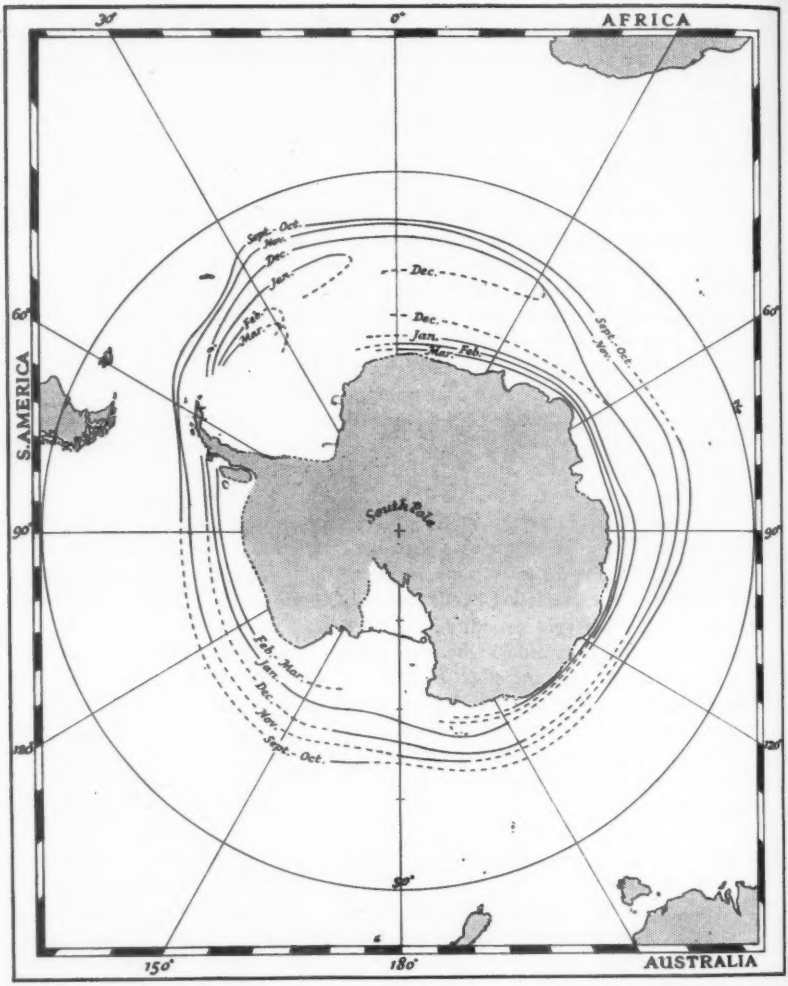


Fig. 4. Mean positions of northern fringe of the pack-ice in summer (from Discovery Reports, vol. XIX)

was maintained almost throughout and enabled a very full routine of observations to be successfully carried out.

The seventh and last cruise which began on February 15 was in many respects similar to the sixth. The pack-ice seems generally to be at its lowest ebb about late February and early March. The middle of February is thus an ideal time to leave Cape Town for a straight run down to the Antarctic continent, and on this cruise the ship did in fact find clear water up to the continental barrier.

The southward passage went according to plan, though the weather was not quite so favourable as on the previous occasion. On March 3 barrier ice was sighted in 69° 15′ S., 00° 15′ E. The ship lay-to that night; her position was fixed by stellar observations, and next morning she proceeded to follow the edge of the barrier towards the east. The course taken is shown in Fig. 5, which needs little explanation. At first it was uncertain whether this was in fact the fixed barrier or a detached ice island, but in the afternoon of that day, when the ship was close alongside the ice-cliff, land was clearly seen about 5 miles to the south. About 25 miles farther east a patch of heavy pack-ice necessitated a detour to the north, but the barrier was found again in 03° 30′ E., and the land was sighted at intervals during March 5 between 03° 40′ E. and 04° 20′ E.

During these two days soundings were carried out continuously, and it is

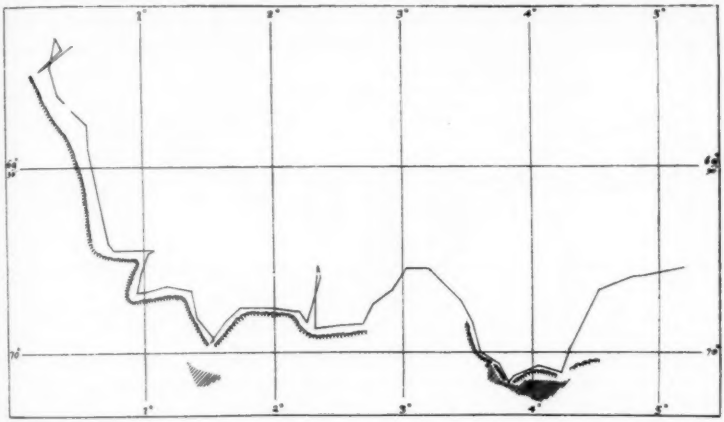


Fig. 5. The ice-barrier in 70° S. between 0° and 5° E. Thin line is ship's track, land shaded

specially remarkable that there was practically no sign of any continental shelf such as was found off Adélie Land and expected in some form off any coast bordering the open ocean. Where the barrier was first encountered some distance from land it was floating in 1114 fathoms, and as it was followed towards the land the soundings shoaled rapidly to 160 fathoms, part of the slope being as steep as 1 in 6.

The height of the barrier cliffs varied from 70 to 120 feet, and at some points many large tabular bergs were packed against it in a chaotic mass, but there were no off-lying rocks. Captain Hill says in his report that there were no mountains or peaks where the continent was first seen, but the land rose gently to the south as a snow-covered plateau, and was lost to view in the distance at a height of about 2000 feet. The land seen on the following day was similar. Here several snow-covered nunataks were visible and some morainic material or rock was seen at the base of one of the slopes. To make a landing on such a coast would have been extremely difficult. It was thought

to be possible at one point, but there was an accident to the engine of the motor boat, fuel was running low, and it was thought better to move on to examine more of the coast to the east. On the night of March 5 however the weather broke up, pancake ice was forming rapidly, and further exploration had to be abandoned.

It does not appear that this can be claimed as newly discovered land. According to the Handbook and Index to accompany the Australian Government's Map of Antarctica, the German ship *Schwabenland*, with two aeroplanes, was in that neighbourhood a few weeks earlier. The ship herself did not apparently come quite up to the land, but flights were made between 1° and 7° E. during which some of the same land was probably seen. Land had also been charted some years earlier in this part of the Antarctic by the *Norvegia*, though it does not appear that they saw the same part of the coast as the *Discovery II*. Perhaps the most important aspects of the *Discovery II's* visit lie in the soundings, the charting of the position of the barrier at that time, and a fairly accurate determination of the position of a part of the coast.

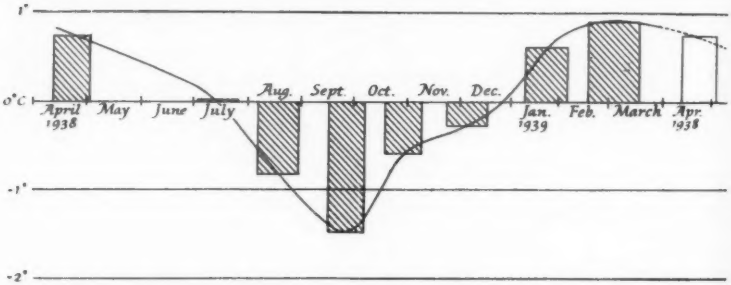


Fig. 6. Mean seasonal deviation from mean temperature, 0–100 m. layer

When the *Discovery II* finally left the barrier there was insufficient fuel for the usual tack to the north-east and south-east, and she steamed away on a north-easterly course until she reached 20° E. in 60° S., and then turned north to Cape Town. There is little more to relate. After a few days at the Cape the ship began the homeward voyage on March 29. On the homeward voyage we generally take the opportunity to fish large nets at intervals in deep water. Although oceanic organisms are less abundant in temperate and tropical waters than in the Antarctic, the variety of species is much greater, and in this way the Discovery Committee's biological collections can be greatly enriched. The route is generally varied a little, and this time the ship called first at Elephant Bay, and in addition to the net hauls, worked a line of full stations in the Gulf of Guinea in order to obtain some information on the Equatorial and Guinea currents. Fuel was taken at Dakar and the ship reached London on 9 May 1939.

The circumpolar voyage and the repeated cruises have provided a very large body of data, and even in peace time a long period would be needed for its detailed examination. In war time of course we are able to make little progress, but some of the material has been subjected to a preliminary

examination, and it would not perhaps be out of place here to give one or two examples of the kind of information which the data from the repeated cruises will furnish. The sea temperature is probably the most important factor which influences the distribution and life cycles of marine organisms, and we therefore require to know something of the range of seasonal fluctuations of temperature. Fig. 6 illustrates a provisional statistical analysis by Mr. Clowes and Mr. Nicholson of all the temperature readings taken between the surface and 100 metres in each of the repeated cruises, including the preliminary one in April 1938. The curved line may be described as showing the mean seasonal deviation from mean temperature in the superficial stratum of water, and it is simply intended to show in a general way how the temperature rises and falls at different times of year. We see that it falls to a minimum about September or October and rises to a maximum about February or March. Some irregularities in the curve may be attributed in part to the effect of freezing and melting of ice which need not be discussed here.

Fig. 7, drawn by Dr. Hart, illustrates another important point, namely the

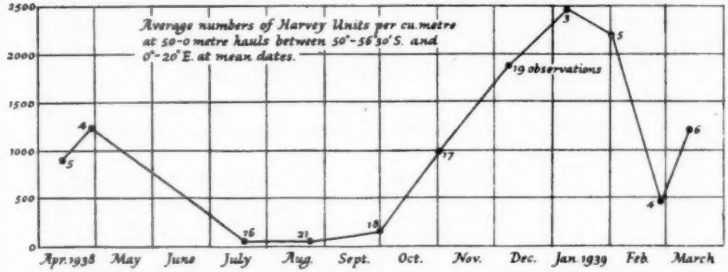


Fig. 7. Seasonal variation of phytoplankton in north Antarctic zone

seasonal variation in the abundance of phytoplankton. This again is a provisional analysis, based only on a preliminary examination of the material. The phytoplankton includes all the minute vegetable organisms (mainly diatoms) which constitute the basic food material on which all the marine fauna directly or indirectly subsists. The curve shows the enormous growth of this vegetable matter in summer, reaching a maximum in January. There is a second, smaller crop in April, and it is reduced almost to nothing in winter. The phytoplankton plays much the same part in the sea as the grass does on land. The crustaceans which form the food of whales are among the animals which feed directly on it, and it is evident that they can find little to eat in winter; in fact we find a corresponding slowing down in their winter growth. Fig. 7 shows the conditions in the northern part of the Antarctic surface water. Farther south the maximum would be a little later, and farther north it would be earlier.

These are two straightforward examples of the way in which the data can be treated, and it will readily be seen that seasonal comparisons can be made of a variety of physical, chemical, and biological data, and that variations can be examined in different latitudes and in different strata.

It would be no use speculating on the possibility of resuming any of this

work with the *Discovery II* after the war, but I hope some form of work in those regions will be continued, as there is a very wide field for research. In the meantime there is much work to be done at home, so far as such matters can claim attention in these days, for so long as the ship was at sea the data and material accumulated more quickly than they could be fully examined and reported upon.

DISCUSSION

Before the paper the CHAIRMAN (Mr. LEONARD BROOKS) said: The President cannot be with us to-day, and I have been asked to take his place. Dr. Mackintosh, who is a member of the Council of the Society, is to read a paper on the last commission of the R.R.S. *Discovery II*. He is, as I suppose many present know, a zoologist who made many voyages in the Antarctic in the early days of the Discovery Committee's work, and a few years ago succeeded Dr. Stanley Kemp as Director of Scientific Research in London. He will speak to us of the commission of the Committee's ship, the R.R.S. *Discovery II*, which returned home about the beginning of the war after a singularly interesting and successful voyage. We all hope that, although it was for the moment the last voyage of this ship, means will be found after the war to continue the valuable oceanographic work which the Committee has promoted for the last twenty years. I now ask Dr. Mackintosh to read his paper.

Dr. Mackintosh then read the paper printed above.

The CHAIRMAN: Is there anyone who wishes to make a contribution on the subject or to ask a question?

Sir PERCY SYKES: Is there any estimate of the whale population and will the whale population increase owing to the present world war?

Dr. MACKINTOSH: Any kind of census of the whale population is extremely difficult to make. One method is to make an analysis of the number of whales we have seen from time to time and try to work out what number of whales may exist in a given belt of water which we study as the ship steams through it. That is a procedure likely to result in inaccuracy because of varying weather conditions, varying visibility, and so on. The most one could do would be to fix a minimum and maximum which would be rather wide apart. I would not care at the present stage to make any such attempt. I think however that present war conditions should be beneficial to the stock of whales because whaling has undoubtedly greatly diminished. If the experience of the fishing industry in the last war is anything to go by—and it is, in some ways, analogous—the present war should be giving whales a much-needed rest.

The CHAIRMAN: It only remains for me, on your behalf, to thank Dr. Mackintosh for a most interesting lecture, lantern slides, and films.

THE OUSE FLOOD PROBLEM

W. E. DORAN, B.A.I., A.M.I.C.E., Chief Engineer, River Great Ouse Catchment Board

Meeting of the Society, 7 April 1941

CERTAIN aspects of the Fenlands have been the subject of valuable and interesting papers published in the *Journal* of the Society.[1] The purpose of the present paper is to analyse the difficulties in regard to drainage which present themselves in the area drained by the Ouse system and to explain the proposals which have recently been adopted by the River Great Ouse Catchment Board. The catchment area of the Great Ouse and its tributaries amounts to approximately 3200 square miles, being somewhat less than that of the River Thames which has a catchment area of 3812 square miles up to Teddington Weir.

The main river Ouse rises in Buckinghamshire and flows through Bedfordshire and Huntingdonshire to Earith, picking up, in its course, various tributary streams, such as the Tove, Ouzel, Ivel, Kym, Alconbury Brook, etc. Between Earith and Welmore Sluice, about $1\frac{3}{4}$ miles upstream of Denver Sluice, there are two artificial channels known as the Old Bedford and the New Bedford or Hundred Foot River. These were constructed in the seventeenth century by Sir Cornelius Vermuyden, a Dutch engineer, employed by the fourth and fifth Earls of Bedford to carry out the drainage of the fens. Prior to the construction of these channels the main waters of the Ouse flowed by Stretham, Ely, and Littleport, and so to Denver. There was also another branch which flowed westwards to join the Nene.[2] Under present-day conditions none of the Great Ouse water flows into the old course *via* Ely, the connection being used only for navigation. The Hundred Foot River is tidal as far as Earith, in fact high spring tides are felt as far as Brownshill Staunch about $2\frac{1}{2}$ miles above Earith. Along the east bank of the Hundred Foot there is a high bank known as the South Level Barrier Bank, the top of which is more than 20 feet above the level of the land behind it in some places. The west bank of the river, while high enough to prevent the tide overflowing into the Washlands, as the area between the two rivers is called, is low enough for some distance below Earith to permit flood water to spill over it.

The Old Bedford River has sluices at Earith, known as Seven Holes Sluice, which are opened only when the water-level in the Ouse has reached a stipulated height and, at its northern end, there are sluices where it joins the Hundred Foot at Welmore whereby the entry of the tide is prevented. Along the west side of the Old Bedford is a high bank, known as the Middle Level Barrier Bank, corresponding to the South Level Barrier Bank along the Hundred Foot. There is no flood bank along the right bank of this channel, so that, when Seven Holes Sluice is opened, the water is free to spill from the Old Bedford on to the Washlands. In flood time water also enters the Wash-

[1] 'Extinct waterways of the Fens,' Gordon Fowler, January 1934. 'The origin of Roddons,' H. Godwin, March 1938.

[2] See 'Extinct waterways of the Fens.'

lands by spilling over the roadway at Earith. The Washlands, which have an area of about 5000 acres, act therefore as a flood reservoir and can store the flood waters of the Ouse during the time that the gates at Welmore are closed by the tide. These Washlands are commonly flooded for some months each year.

This reservoir effect of the Washlands is not however their only function. Owing to the considerable width between the South Level Barrier Bank and the Middle Level Barrier Bank they are capable of passing a heavy flood discharge along the 18 miles between Earith and Welmore with a comparatively small surface gradient. This important point has apparently escaped the attention of various writers on the subject.

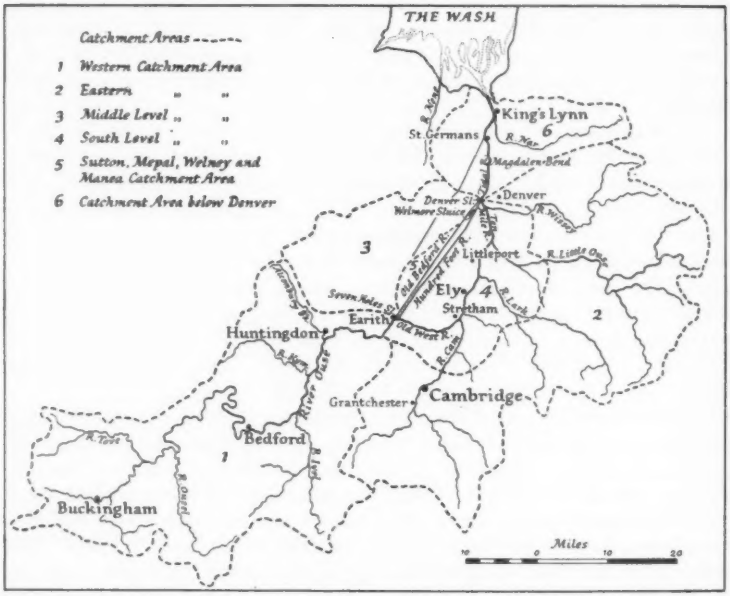


Figure 1

The area which drains into the Ouse down to Earith, which I shall refer to as the Western Area, amounts to 1175 square miles (Fig. 1, No. 1). The next main division of the catchment area, which I shall call the Eastern Area, (No. 2) is slightly larger, being 1441 square miles in extent and drains into the old course of the river between Earith and Denver. It comprises the catchment areas of the rivers Wissey, Little Ouse, Lark, Cam, and various lodes, and receives also practically all the water from the fen pumps in the area east of the Hundred Foot River. This area, comprising the fenlands lying between the Hundred Foot River and the higher silt-land, is known as the South Level (No. 4) and looms very large in our drainage problem. All the rivers of the Eastern Area pass through it in a high level system which I shall

refer to collectively as the South Level System. The fenlands themselves are drained by a network of drains which carry the water to pumping stations which lift it into the main watercourses. The term "lode" is applied to various small canals for the purpose of navigation and also to take water from the highlands into the Main River. The lodes are fitted either with locks or with timber pointing doors where they enter the main river system. If the banks of the lode should give way the doors prevent the water in the main river from flowing back up the lode and pouring through the breach.

The Middle Level (No. 3) drains to St. Germans. The drainage of this area was by gravity until 1934, when a large pumping station, having a capacity of 2520 tons of water per minute against a static head of 10 feet, was erected, gravity drainage having become ineffective. Lying between the Middle Level Barrier Bank and the Middle Level is area No. 5, comprising the Sutton and Mepal District and the Manea and Welney District, which pump into the channel which has its outfall at the Old Bedford Sluice opposite Denver Sluice. The remaining area, No. 6, comprises the River Nar Catchment and various drainage districts below Denver. All these areas are concerned, to a greater or lesser degree, in a satisfactory solution of the problem.

The discharge from the Eastern Area unites with that from the Western Area at Denver where it is admitted into the Tidal River through Denver Sluice. Owing to the tidal rise at Denver the discharge from the South Level system is intermittent and, during periods of high flood, the quantity which can be discharged during the tidal period is less than the amount being carried down by the various rivers, with the result that dangerously high water levels occur upstream of Denver.

When Vermuyden commenced his operations in the seventeenth century, comparatively low flood banks were all that were necessary to prevent the flooding of the land, and drainage was entirely by gravity. In 1678 we find the first mention of mills for pumping and, by 1748, there were two hundred and fifty windmills in the Middle Level area alone. The windmills lifted the water by large wheels, called scoop wheels, fitted with paddles. As the fens sank the wheels had to be increased in diameter and were sometimes as large as 50 feet. Later the windmills gave place to the steam engine, then the centrifugal pump was substituted for the scoop wheel, and finally the steam engine was supplanted by the diesel engine. To-day practically all the drainage of the fen area is by pumps, and we have some ninety pumping stations in the catchment area.

The increased necessity for pumping has been brought about by the wastage of the peat surface of the fens.[1] It is on record that, before the fens were drained, the level of the land was 5 feet above that of the adjacent silt-land, while, at the present time, much of it is 10 feet below the silt-land level. The wastage of the peat surface is due in part to denudation of the loose peat by the action of wind and rain which carry it into the drains, in part to the operations of agriculture, and last but not least to the bacteria which act on the dry peat and cause it to break down so that it is carried away in solution by rain water. It is apparent that eventually the whole peat surface must disappear. This sinking of the land surface, which has been proceeding for

[1] For measurement of shrinkage in Denton Fen see "The shrinkage of peat-covered Fenlands," Gordon Fowler, *Geogr. J.*, February 1933.

centuries and which still continues, is the basic cause of the trouble with the river embankments and is one of the principal difficulties to be overcome in putting forward any effective solution to the whole problem.

Since the water level in the rivers is governed ultimately by the tide level the sinking of the land surface rendered it necessary to increase the height of the flood banks along them, and to-day all the rivers flowing through the fens are embanked waterways. The original bank along the Hundred Foot is stated by Dugdale [1] to have been 8 feet high with a base of 60 feet and a top width of 10 feet. It is interesting to compare this with a section of this bank as it is at present (Fig. 2). This sinking of the banks still continues, and is estimated to amount to between 1 inch and $\frac{3}{4}$ inch per annum on the average.

The original drainers could not possibly have foreseen the result of their

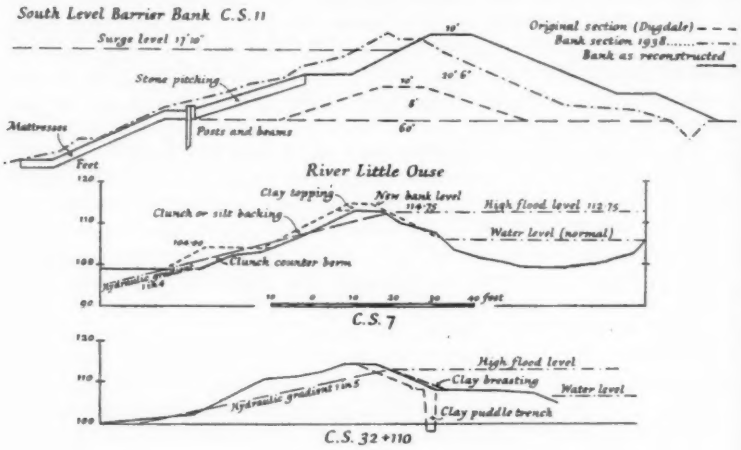


Figure 2

operations. Had they done so they would no doubt have left room, both at the front and at the back of the banks, for future heightening operations. As it is however, further heightening is very difficult in many cases, while past heightening of the banks has resulted in their becoming too high in relation to their width at the base. A further difficulty is that the original banks were composed of the only material locally available, namely peat, and they rest of course on a peat foundation, so that when they are subjected to high water levels, seepage takes place through them and, apart from the fact that this seepage is objectionable in itself and has to be pumped back again into the river, the banks may fail through "blowing-out" at the toe. Many failures of this kind have occurred. Typical bank sections illustrative of these difficulties are shown in Fig. 2. In Section C.S. 7 there is insufficient room on the face of the bank to follow the usual practice of breasting the bank with clay, so that the only alternative is to make up the bank from the back. This fre-

[1] 'History of imbanking and draining of divers fens and marshes,' William Dugdale. 1772 Edition, p. 415.

Middle Level Barrier Bank: filling puddle trench and placing clay

Hundred Foot River Bank: breached during tidal surge, February 1938

Lakenheath Lode 1939 flood: bank level raised by bagwork

Soham Lode breach 1939

quently involves setting back an existing roadway or a ditch at the back of the bank in order to obtain the necessary room. The hydraulic gradient (*i.e.* the maximum gradient between the point of entry and exit of water) of 1 in 4 shown on the section is the general minimum standard adopted for bank sections in the fen area. In Section C.S. 32+110 there is sufficient foreshore for clay breasting, but owing to the nature of the bank, this is insufficient to prevent seepage and a deep cut-off trench has had to be excavated and filled with clay. A considerable amount of this kind of work has been carried out and, in fact, about £350,000 has already been spent on the banks in the South Level area alone.

We have now almost reached the limit of what can be done in this way on some of our banks, and those which were made up with clay some years ago now need similar attention again. During high floods, such as that which occurred in March 1937, the water may rise to such a level that, apart from the danger of the banks bursting and the leakage due to seepage, the water level is actually higher than the tops of the banks in some places and disaster is only averted by raising the bank tops by bag work. In the floods of 1937 and 1940 men worked twenty-four hours on end on this work, and it was impossible to say how much longer the overstrained banks might hold out.

It is evident therefore that, if it is not practicable to raise the banks, some means must be found to prevent the water levels from rising so high. This naturally leads to the question of how high the water could be allowed to rise without endangering the banks. While there is no definite level applicable to all banks it has been decided that a level of 10·0 feet above Ordnance Datum (Liverpool M.S.L.) would be safe level.[1] During the 1937 floods the water level reached 12 feet 9½ inches at Ely and was above the maximum safe level of 10 feet for thirty-three days. In 1939 the level was exceeded for eleven days, and in 1940 for fourteen days.

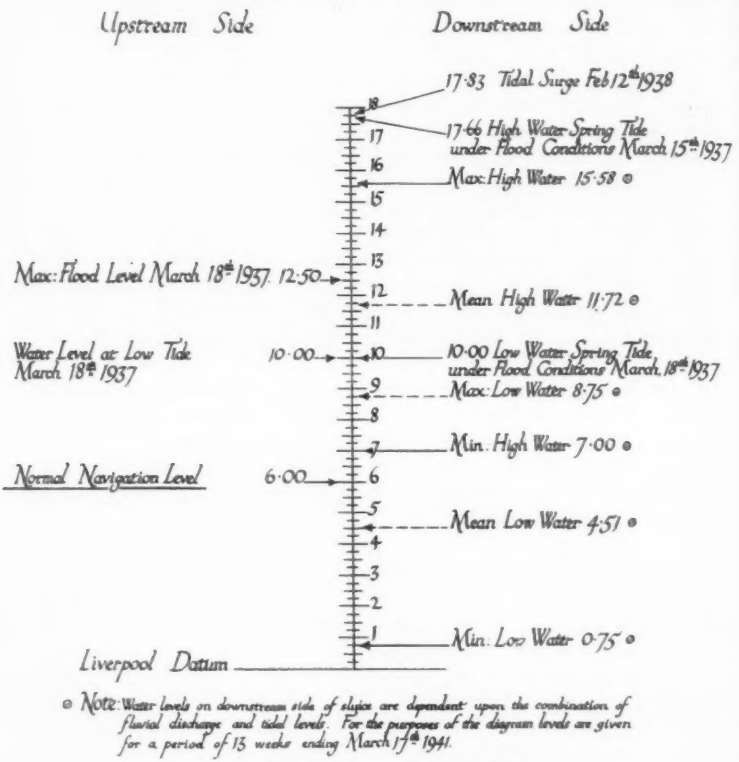
As I have mentioned earlier the point of discharge of the South Level system into the Tidal River is at Denver. During the floods of 1937 the low water level at this point during spring tides was 10·0 feet, so that, unless this discharge level can be lowered it will be impossible to lower sufficiently the high flood level in the South Level system (see Fig. 3).

The surface gradient of the Tidal River between Denver and St. Germans at low tide exceeds 12 inches per mile, and most of the improvement schemes advanced in the past have been designed to lower the low-tide level at Denver by widening, deepening, and straightening the Tidal River so as to reduce this gradient. The first of such proposals was that put forward by Mr. W. H. Wheeler in 1884. Subsequent schemes on similar lines were advanced by Mr. Havelock Case (1916), Mr. W. E. J. Binnie (1927), and Mr. H. Kraaijeveld (1930). All except the first provided for the construction of training walls extending into the deeper water in the Wash, in addition to the works in the Tidal River.

The Wash is a natural receptacle for silt which is produced by coastal erosion, and the outlets of the rivers flowing into the Wash are considerably obstructed by shoals. The Ouse, owing to its situation in the south-east corner of the Wash, is probably more affected by silt than any of the other rivers, and

[1] 'Report on flood protection,' Sir M. MacDonald and Partners, p. 29.

the tidal water coming in over these silt banks becomes heavily charged with silt and carries it up into the river. Since the velocity of the flood tide is greater than that of the ebb the tendency is for the tidal water to deposit more silt as it comes in than is removed by the subsequent ebb. The sectional area of the channel therefore may be regarded as the resultant of two opposing tendencies, the silting action of the tidal water and the scouring action of the fluvial water and consequently, unless the silt can be excluded, any widening



⊙ Note: Water levels on downstream side of sluice are dependent upon the combination of fluvial discharge and tidal levels. For the purposes of the diagram levels are given for a period of 13 weeks ending March 17th 1941.

Fig. 3. Water levels at Denver Sluice

of the Tidal River would be ineffective because it would silt up again until the balance of forces was restored. The construction of training walls was suggested therefore in order to prolong the river channel through the shoals, and also to prevent the ingress of silt. Considerable emphasis was laid on the necessity for improving the outfall, and in fact a kind of tradition arose that it was essential to carry the outfall channel through to the "blue water." Notwithstanding the emphasis on this side of the problem the main function of the training walls was to exclude silt because, although the maintenance of a sufficient channel through the shoals would no doubt lower the low-tide level

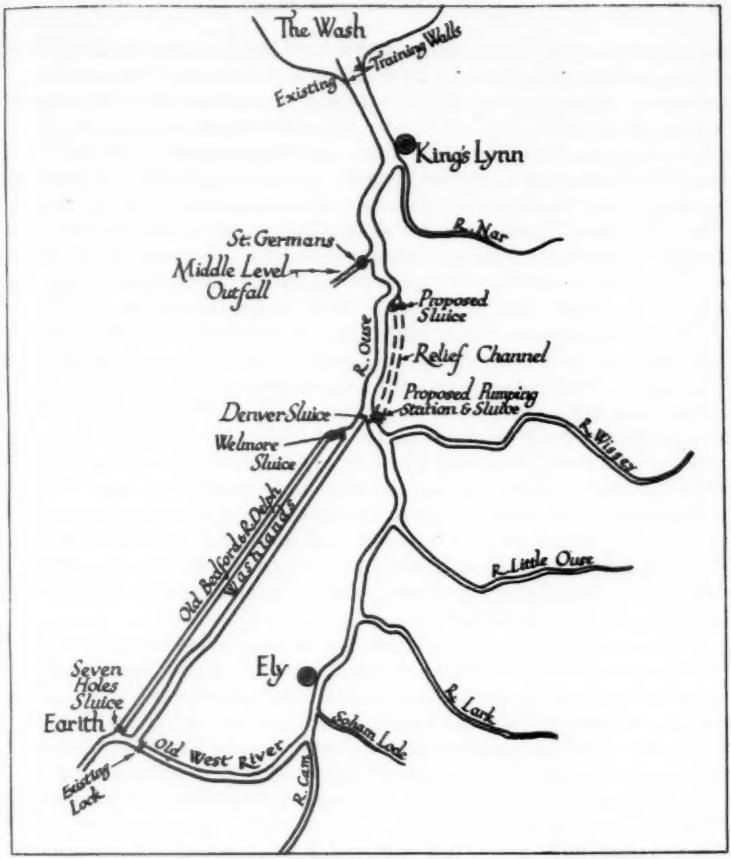


Fig. 4. Sir Alexander Gibb and Partners' proposal, January 1939

at King's Lynn, calculations show that this lowering would not be sufficient to have any appreciable effect at the point of outlet of the South Level waters at Denver, 13 miles away.

The most ambitious of the schemes mentioned was that proposed by Mr. Kraaijeveld which provided for training walls extending over 5 miles into the Wash to the Lynn Channel, while the Tidal River and Hundred Foot were to be widened and lined with stone. The cost of this project was estimated at £5,820,000 in 1930. This sum did not provide for any of the work which would be necessary in the South Level and in the Upper Reaches of the Catchment Area.

Another solution suggested was the construction of a barrage at Free Bridge, King's Lynn, with the object of utilizing the storage above it in time of flood. Towards the end of October 1938, Sir Alexander Gibb and Partners were consulted by the Association of Internal Drainage Authorities within the South Level and their report appeared in the following January (Fig. 4). In

this report they point out that any attempt to widen or deepen the Tidal River channel is likely to be defeated by silting, and go on to say "Any attempt to enlarge or deepen parts of the tidal channel of the Ouse (short of carrying training banks far out into the estuary to a point where sea water is clear of silt) is likely to result in partial failure and disappointment. On the other hand, the expense of a complete scheme with training banks a distance of 6 miles into the Wash Estuary would be very great and the results uncertain." They put forward a proposal for the construction of a relief channel from Denver to Magdalen Bend with the provision of a large pumping station at Denver. There would be sluice gates at each end of the channel. Under this scheme, the South Level water would flow by gravity until the rising tide rendered necessary the closing of the gates at the outlet at Magdalen Bend. The sluices at the Denver end would next be closed and the pumps started. The pumps would thus maintain the flow upstream of Denver, while on the downstream side of the pumps the water would continue to rise, until its level permitted its discharge into the Tidal River at Magdalen. Pumping would continue until the falling tide enabled gravitational flow to be resumed. This was a most interesting and constructive proposal. The estimated cost was £649,000, a remarkably low figure when compared with the schemes previously put forward. As will be shown later however the relief afforded by the scheme was not really sufficient, and it did not provide for the necessary work outside the South Level area. Such in brief were the proposals put forward up to 1939 for dealing with the problem.

In the past eight or nine years much detailed information has been obtained by the engineers of the Catchment Board, including the results of some five years' investigation of the problem with a Tidal Model, information which was not available to the authors of the earlier schemes mentioned. In consequence, the flood discharges which have to be provided for and other factors, which must be taken into account, are now more accurately known.

In May 1939, the Catchment Board requested Sir Murdoch MacDonald and Partners to report upon the problem. The Consulting Engineers' report was presented in August of last year, and in this report they have reviewed the principal previous proposals and commented on the effect that they would have had if they had been put into operation. One of the basic questions to be settled in considering the problem is the discharge which must be provided for. A large number of discharge sites have been established by the Catchment Board and discharge readings were taken during the floods which have occurred since 1936. Based upon these readings Sir Murdoch MacDonald and Partners arrived at the discharges which they considered should be allowed for in any scheme of flood protection. The figure which they finally arrived at is 13,000 cubic feet per second as the combined discharge of the Eastern and Western Catchment areas. One would not expect to get a maximum discharge simultaneously in both areas, and it is considered that this 13,000 cusecs might occur as follows:

Western Area	7700 cusecs *or*	6700 cusecs
Eastern Area	5300	6300

The maximum discharge to be provided for from the South Level therefore is 6300 cubic feet per second.

Of proposals which provide for widening the Tidal River and constructing training walls in the estuary, Mr. Kraaijeveld's scheme is taken as an example because this is the most extensive of the schemes proposed, and it is calculated that, with this scheme in operation and the discharges mentioned, the low-water level at Denver would be 7·0 feet. In these circumstances, when Denver Sluice was closed against the tide, the level upstream would rise to at least 11·0 feet. At Denver and Ely, and everywhere south of it, the high-water level would be well above the "danger line" of 10·0 feet. In addition to this it would be necessary to widen the river between Denver and Ely, which was not provided for in the Scheme.

With regard to the action of the training walls, the opinion is expressed "that, although there would be a diminution in the amount of silt, the very best that can be said for such a scheme is, that *probably* it might be successful in maintaining the new channel without recourse to constant dredging." Notwithstanding the great expense involved in the scheme therefore the results to be expected from it would not amount to an effective solution of the the problem.

With regard to the intermittent barrage at Free Bridge, it is shown that the benefit conferred on the South Level would be very small, while there would be a strong probability that considerable silting would occur below the barrage.

With regard to Sir Alexander Gibb and Partners' proposal, it was stated by them that it would result in obtaining a level of 7·0 feet upstream of Denver Sluice and that the level at Ely would be 5 feet higher than this, viz. 12·0 feet.[1] This is 2 feet above the safe limit, so that the proposal, as put forward, would not solve the difficulty.

By widening and deepening the river between Denver and Ely the level at Ely could have been reduced, but there would be the considerable expense of constructing and maintaining a large pumping station at Denver which would be required only during heavy floods. Furthermore, the flood water from the Uplands would continue to flow through the fens and, as the embankments will sink with the wastage of the peat, further extensive work would become necessary in the future.

It is evident that none of the schemes described afford a satisfactory solution of the problem.

While Sir Murdoch MacDonald and Partners were engaged upon the investigation of the problem, a proposal was submitted for their consideration by Mr. W. M. Griffith, A.M.I.C.E., a member of the Board's staff. This proposal was considered by the Consulting Engineers to be superior to any of the previously considered projects, and a scheme on the lines suggested by Mr. Griffith is recommended for adoption if the larger scheme put forward by the Consulting Engineers as a complete and permanent solution is not adopted.

Briefly Mr. Griffith's proposal is as follows. The Tidal River between Denver and St. Germans is admittedly too small to carry a flood discharge at the desired level and the surface gradient is correspondingly steep, being over 12 inches per mile. Below St. Germans however the river is an artificial cut, known as the Eau Brink Cut (made in 1821), and is of adequate dimensions. The material excavated in making the cut provides strong flood banks. By

[1] Sir Alexander Gibb and Partners' Report, p. 12.

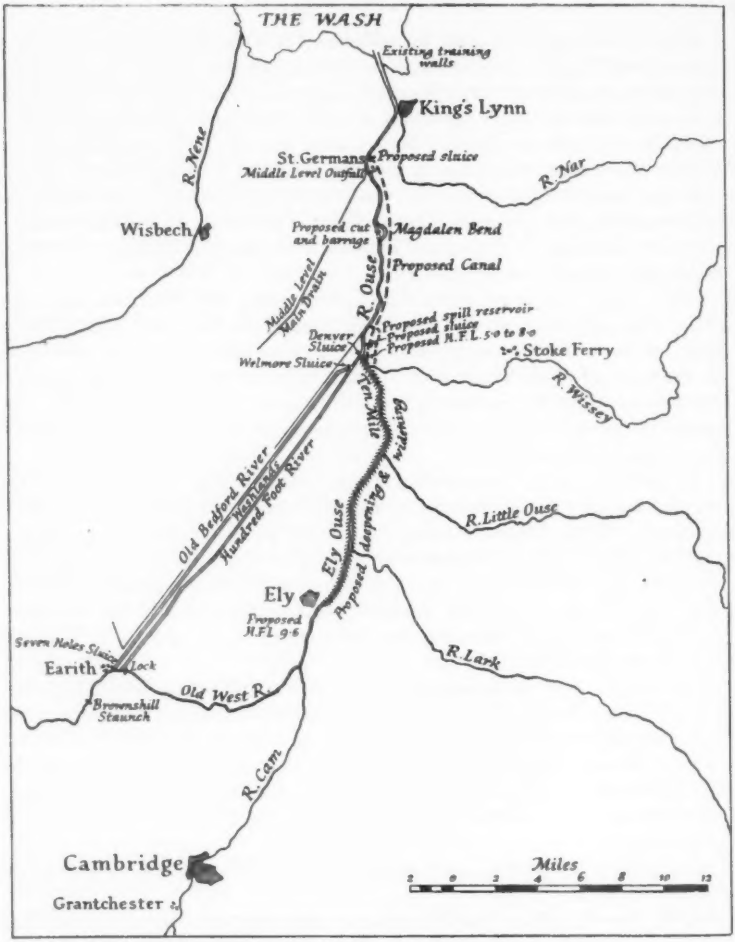


Fig. 5. Mr. Griffith's proposal April 1940

making a new canal between Denver and St. Germans (Fig. 5) it will be possible to obtain a much flatter surface gradient and, as this canal would be used only in time of flood, there would be no danger of it silting up. The tidal rise at the outlet of the canal will prevent the discharge of water during a certain number of hours on each tide and, in order to prevent the water backing up in the South Level during this period, it is proposed to construct a spill reservoir immediately below Denver to receive the South Level discharge during the period of tidal closure. In this way a continuous discharge is secured.

By this means it will be possible to obtain at Denver a low-water level of 5·0 feet, while the maximum level will not exceed 8·0 feet. In order to take

advantage of these levels at Denver it will be necessary to reduce the surface gradient in the river between Denver and Ely, and this can be done by widening and deepening the river. The effect of these works, under flood conditions, is shown in the accompanying table which shows the calculated levels as compared with those which occurred during the flood of 1937 (Fig. 6).

In the 1937 flood the discharge was 4677 cubic feet per second as compared with 5370 cubic feet per second provided for in the calculation. It will be seen that, under these conditions, the level at Ely will be 9 feet 5 inches and a level of 10 feet will occur some distance south of Ely. This level will be exceeded in the extreme southern portion of the South Level, but there is no reason for any apprehension on this account, as the excess will be very slight. It will be noted that the discharge provided for in the calculation is 1000

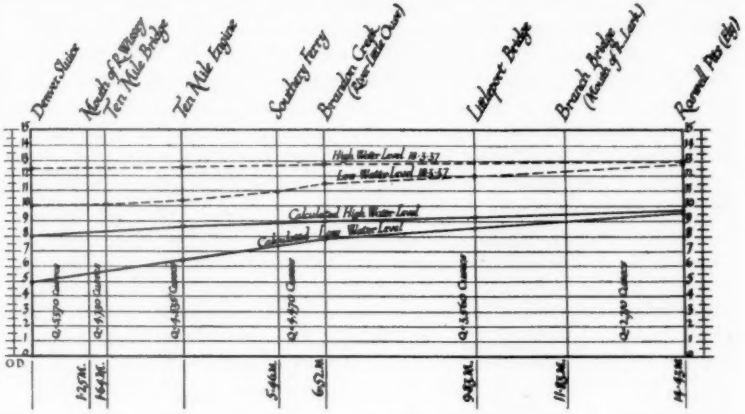


Fig. 6. Calculated levels under Mr. Griffith's proposal compared with flood levels 18 March 1937

cusecs less than the maximum estimated discharge, the reason for this difference being that a certain amount of storage will occur on the peak of the flood. The effect of this is that the calculated levels will be slightly exceeded, but this will occur for a very short period only.

There is another work of considerable interest and importance provided for in Mr. Griffith's scheme. This is the straightening of the river at Magdalen Bend and the construction of a barrage in the straightened portion. This barrage has two main objects. One is the protection of the banks above the barrage from the effects of a tidal surge. It has happened in the past that tides, considerably higher than the predicted levels, have occurred, and such tidal surges, as they are called, have actually reached the level of the top of the banks. It was a tide of this kind in the Thames that caused the disaster at Millbank in 1928 while, in February 1938, the South Level Barrier Bank was topped and breached above Denver by a tidal surge. In present circumstances the Tidal River banks cannot be considered safe because of tidal surges of this kind. With the suggested barrage however the gates can be lowered in case of

an exceptional tide, thus rendering it unnecessary to heighten considerably the river banks above this point. The main purpose of the barrage however is to secure that the river bed does not rise because, with a gravity outfall scheme, it is necessary that there should not be any danger of a rise in the low-water levels. As has already been stated, the reason why tidal silt is deposited in the river is that the velocity of the flood tide is always in excess of that of the ebb. By the operation of the barrage it will be possible to correct this state of affairs. This will be done by admitting the tidal water in the ordinary way and closing the barrage at high water, the gates of the barrage will remain shut until there is a predetermined difference in level between the upstream and downstream sides and the gates will then be opened, the water thus released will flow out at a much higher velocity than it otherwise would have done, thereby securing adequate scouring action in the river. It might be thought that the effect of using a barrage in this way would be local, but extensive model experiments carried out at the Board's Hydraulic Laboratory show that such is not the case, and that the scour extends from some distance above Denver Sluice right to the end of the present training walls, and there seems to be no doubt that this barrage offers a guarantee that the river bed can be maintained at a satisfactory level. In addition to its beneficial effect upon drainage the barrage will also benefit the Port of King's Lynn by securing a greater depth in the river channel.

There are two other items which should be mentioned in connection with the project. The sum of £110,000 is provided for raising, strengthening, and setting back the banks of the Tidal River where necessary, as there are many places where the river is too narrow and where the banks are not safe. The other item amounts to £90,000 and allows for certain work necessary in connection with the areas which drain into the river between Denver and King's Lynn. This will mainly consist of pumping stations and the modification of existing outfalls.

It will be observed that, in Mr. Griffith's scheme, the Upland waters still flow through the South Level and, if the fenland continues to sink, there will come a time when some other steps will have to be taken to provide for the safety of the Fens. Assuming that the rate of sinking is in the neighbourhood of three-quarters of an inch per annum the scheme just outlined will probably provide safety for the next sixty years or so. Before describing the project of Sir Murdoch MacDonald and Partners there is yet another scheme to be mentioned. This is the Amended Scheme of Sir Alexander Gibb and Partners (December 1940) (Fig. 7). Unfortunately space does not permit of any detailed consideration of this very interesting and ingenious proposal, but, briefly, the essential features are the construction of a relief channel from Denver to St. Germans, capable of dealing by gravitational flow with the discharge of the South Level system from a point some distance south of Ely down to Denver and the construction of a large pumping station at Earith to take the flow *via* the old course of the river known as the Old West River from the southern end of the system including the River Cam. These pumps would discharge into the Hundred Foot River.

Since there would be a considerable increase in flow on to the Washlands under this scheme a new channel would be made between Welmore and

Tidal Model: experimental training walls in position

Chimney Mills Lock: collapse of wall during flood, January 1939

Tidal Model: River Great Ouse

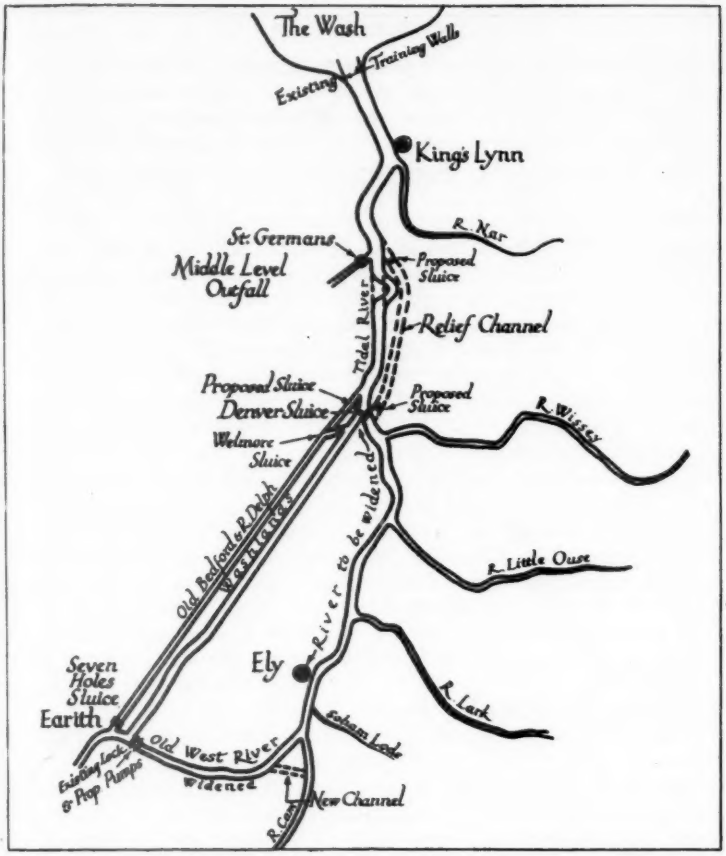


Fig. 7. Sir Alexander Gibb and Partners' amended proposal, December 1940

Denver to increase the discharge from the Washlands. Even allowing for improvement brought about by work on the Washlands and the discharge channel at the lower end, the Board rejected the proposal to discharge water from the South Level down the Hundred Foot River and Washlands; in addition there is the disadvantage of the maintenance of a pumping station of nearly 4000 horse power to lift the water into the Hundred Foot.

We now come to the consideration of the plan proposed by Sir Murdoch MacDonald and Partners. This consists in intercepting the Upland waters so that they do not pass through the Fen area, thus the difficulty caused by the sinking of the river banks does not arise. Under this scheme (Fig. 8) practically the only water which would flow in the South Level system would be that from the Fen pumps. This involves constructing a canal from Denver round the borders of the Fenland, picking up the rivers Wissey, Little Ouse, Lark, and Cam, as well as the upper portions of the various lodes. The canal would extend up to Grantchester so as to pick up the Cam above Cambridge.

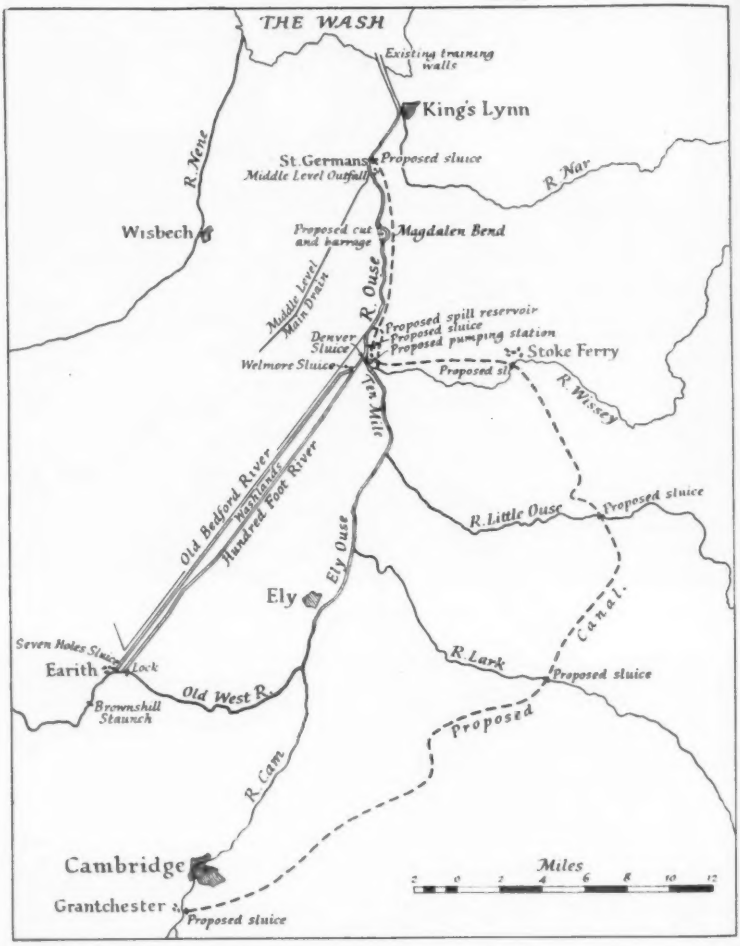


Fig. 8. Sir Murdoch MacDonald and Partners' proposal, August 1940

At first sight it might be thought that, if the canal were taken up to the river Lark, this would be sufficient; but unfortunately the flood discharge of the Cam amounts to nearly one quarter of the total discharge of the Eastern Catchment Area and, as it enters the South Level system at the end most remote from Denver, its diversion into the cut-off is necessary. The level of the water below Cambridge is too low to enable it to be picked up by the cut-off channel, and the channel has to be taken through to Grantchester to obtain a suitable level. Below Denver the proposal is similar to that suggested by Mr. Griffith, and includes his barrage in the Magdalen Bend. Since this cut-off canal would be on the silt-land there would be no danger from sinking, and therefore this solution can be regarded as a permanent one. At Denver

Sluice there would be a pumping station large enough to deal with the water from the fenlands, which could be run in times of high flood, and by this means safe conditions could always be obtained in the South Level area, even when the Fens have sunk very much below their present level. No enlargement in the Ten Mile River would be necessary. The estimated cost of Sir Murdoch MacDonald and Partners' Scheme is £3,810,000.

Reverting once more to the question of the sinking of the fenland surface, it may be pointed out that the difference in cost, amounting to £1,610,000, between the proposal of Mr. Griffith and that of Sir Murdoch MacDonald and Partners is due mainly to this cause. If any emphasis were needed on the importance of this factor in the problem, these figures would supply it.

Hitherto we have been considering the conditions only in the Fen areas, but the difficulties in these areas are by no means all that the Catchment Board has to deal with. There are troubles in the Upland sections of the rivers where considerable unnecessary flooding occurs and where the rivers have suffered for many years from complete lack of maintenance. This state of affairs has certainly affected adversely the drainage of agricultural land, now more important than ever before. Some 50,000 acres in the Upland areas are now being dealt with by the Catchment Board under War Agricultural Schemes, and it is essential that the main rivers should be put in order to reap the full benefit of this important work. It is impossible in this paper to deal with this part of the problem, but it may be mentioned that the estimated cost of the necessary improvements in the Upper Reaches amounts to £350,000, consisting for the most part of dredging work and the reconstruction or remodelling of derelict control structures.

The Catchment Board, after very careful consideration, has recently decided to adopt the proposal put forward by Mr. Griffith, with the addition of the necessary work in the Upper Reaches, and has approved the sum of £2,200,000 for the scheme. It should be pointed out that the cut-off channel extending to Grantchester forms a natural extension of Mr. Griffith's scheme, and therefore if the sinking of the Fens renders it necessary, this cut-off channel could be carried out in the future, unless of course it were decided to overcome the difficulty by the use of pumps.

This is the first time that a satisfactory and practical proposal, supported by reliable data and calculations, has been put forward for the solution of the problem, and it is hoped that we are now within sight of the end of the menace of flooding in the area which includes perhaps the most productive land in Britain.

DISCUSSION

Before the paper the CHAIRMAN (Major-General M. N. MACLEOD) said: The subject of the paper this afternoon is a specially interesting one: "The Ouse flood problem." We are fortunate in having Mr. W. E. Doran, Chief Engineer to the Great Ouse Catchment Board, to state the problem and its solution. Without further ado I ask Mr. Doran to address you.

Mr. Doran then read the paper printed above, and a discussion followed.

The CHAIRMAN: We have not as much time as we would like to spend on this subject, but there are several here who can discuss this interesting paper, and I

call first upon Alderman Jackson, Chairman of the Great Ouse Catchment Board.

Alderman W. C. JACKSON: As Chairman of the Great Ouse Catchment Board I want, first, to thank the Royal Geographical Society for the invitation to Mr. Doran to read his paper, because I feel that he has told you of the very serious problem we have to face on the Great Ouse. Those now living in the Fens are every year facing the acute danger of being flooded out. The position is even more serious at the present time because of the necessity, arising out of the war, of producing more food. An enormous amount of work has to be done in the upper reaches if we are to improve the land for food production. And strangely enough the very fact of land cultivation is increasing the grave danger every winter, and the anxiety of the farmers. If one thinks for a moment about what Mr. Doran has told us with regard to the banks, one can imagine the feelings of those living in the Fens during certain winter months, especially when the rain is heavy. This is therefore a matter with which my Board is very gravely concerned. Moreover, it is a matter of national importance. I do not believe the nation can to-day afford to lose an area containing some of the most fertile land in England merely because of the danger of it being flooded every winter. The invitation sent by the Society to Mr. Doran affords an excellent opportunity of putting the problem before many who will realize the seriousness of the position.

Mr. W. M. GRIFFITH: I congratulate the lecturer on his clear description of this Fen drainage problem, which is rather complicated. Perhaps that is why engineers have offered different solutions. Owing to steady settlement of the Fen and to change in the bed of the Tidal River, the problem itself has somewhat changed in recent years, and a solution which appeared satisfactory to Mr. W. H. Wheeler in 1884 would not appear so now. Mr. Doran has mentioned my scheme which the Catchment Board has accepted. I have had to propose several different works, each having a different function. One novel feature is the scouring barrage. This word barrage has now come to mean a barrier of sluice gates which in modern practice are usually of large span. The idea of constructing a barrage across a tidal river is of course not new. Where it has been tried the results have not however been considered satisfactory; the tidal river below it has tended to silt up, and what scour has been produced has been only local. After study of silt transportation, and with experience of large barrages in India, I am convinced that the failure of such barrages to secure a satisfactory scour in tidal rivers has been due to wrong design and wrong operation. My thanks are due to Sir Murdoch MacDonald and Partners and to Mr. Doran our Chief Engineer, for their support in enabling me to get my design of barrage and method of operation properly tested in the G.O.C.B. tidal model.

The danger of silting in the Tidal River comes from the sea rather than from the river, for silt is of two kinds, and the laws governing their transportation are different. There is ordinary sand, which requires considerable turbulence to transport it, and there is the colloidal or semi-colloidal mixture of clay, organic matter, and the finest sand, which will remain in suspension under very little turbulence. The high rise and fall of the tide in the North Sea causes sand to flow up the tidal river with the flood and return again with the ebb tide; but as the ebb has a lower velocity than the flood, some of the sand is left behind in the tidal river at each tide. The silt coming down with the river water is mainly of the colloidal kind, as the velocity and turbulence in the river are not sufficient to carry sand in any quantity. The only place where the velocity is low enough to deposit this colloid silt is along the sides, and you will find at the sides of the

tidal river and round the edges of the Wash a mud, termed Warp, quite different from the pure sand of the bed. Round the margin of the Wash, where the bed is high enough for some vegetation to grow, this further reduces the velocity, and the colloidal silt settles more rapidly. In consequence the reclaimed land round the margin of the estuary is composed of clay, organic matter, and very fine sand, which is fortunate, for if the reclaimed land were pure sand it would be little use for agriculture.

Sir MURDOCH MACDONALD: I have naturally listened with great interest to Mr. Doran expounding, with the aid of his charts, the condition of the fenlands, and the proposals which we made to rectify the existing state of affairs. I would have been glad had he dwelt at somewhat greater length on the problem of the sinking of the fenlands. The diagrams showed that much banking has in fact taken place in the fenlands during the past several hundred years. The banks now stand very high, so high that, if a breach occurred, very valuable land would be lost.

I had the privilege, on behalf of the Great Ouse Catchment Board, to consider what should best be done to meet the actual position. I was authorized to examine all the schemes that had been put forward hitherto, and to suggest any scheme of my own. I gave a scheme drawn up by myself and my partners which would effectually prevent for all time the flooding of the Ouse; but naturally it is costly. We therefore had to consider what alternative to offer, and concluded that the scheme proposed by Mr. Griffith, with certain modifications, would be the right scheme to adopt. I understand that the Board have recommended that as a mean scheme which might be carried out. The larger scheme would cost £3,500,000 or more, and the smaller scheme somewhere about £2,000,000 in all. In the result the Board are going to get something which will for a great length of time effectually render safe the area through which the water now flows. If the fens continue to sink, the problem then will be whether to raise the banks or to do something in the way of cutting off these streams from flowing into the South Level, and putting them round by the side.

It need not be that the complete scheme be adopted. The Wissey, the Little Ouse, the Lark, and maybe Soham Lode, could be cut off without the great cut which would be necessary to make the Cam join them. The Cam would then have still to flow down the middle area, unless some other method were found of dealing with it. Sir Alexander Gibb and Partners suggested a method whereby the Cam could be dealt with by taking it to the left along the Old West River and putting it into the Washlands. The difficulty about that is that a large pumping station is necessary. But it so happens that if at any future time the Board are willing to consider putting additional water into the Washlands then it would be possible to make a cut round Cambridge by gravity, and thus avoid a pumping station.

There are a whole series of potential methods to make the fenlands area really safe. What has to be decided is, what is likely to be the biggest flood that Nature will send down. In recent years a remarkable series of big floods seem to have occurred. I took these and added to them a small percentage, and the only fear I had was that it might be too small. That was the only possible criticism I could make of the figures I had been using. The schemes which leave the water either in the Washlands or in the South Level are all subject to that disadvantage, that if Nature does send an overwhelmingly big flood down at any time they may not be able to meet the situation.

Captain W. N. MCCLEAN: The flood flow of 13,000 cubic feet per second is only about six- or seven-tenths of an inch of rainfall run-off in a day. That is about half of what happens in a big flood on the Thames, so that the figure for

the Ouse seems to be reasonable in such an area, but I do not know where that is measured. But the really important point is, what will discharge from about Denver or St. Germans? Will the tidal channel discharge 13,000 cubic feet per second throughout the day or only at low water? One wants to know that because how far the storage is filled behind, in the big area of the Washlands and fens, depends entirely on the possible rate of the outflow down the tidal channel.

I should think there is a great deal to be said for a complete barrage system for the Great Ouse. The tidal water going up the Hundred Foot might be equivalent to perhaps half that 13,000 cubic feet per second. But if you cancel that out by a barrage it may easily be that the 13,000 cubic feet per second discharge could be brought to 20,000. A reservoir of some sort to prevent too high a rise of the river system should not be a very difficult problem.

Mr. DORAN: Before replying to the speakers I would like to express my appreciation of having been asked to give this paper.

I had to curtail a little of the paper because of the black-out and particularly that portion in regard to Sir Alexander Gibb and Partners' proposal, much as I would like to have dealt with it at a little greater length; and also the portion in regard to Sir Murdoch MacDonald and Partners' proposal.

Mr. Griffith's opinion that the accretion of land in the neighbourhood of the Wash is due to the silt in water coming down the river is interesting, because Scurtchley, a well-known authority on the Fens and author of the Geological Memoir, although he has much to say as to accretion and silting, never makes that distinction between silt brought up on the bed of the river, and what we call the warp, the very fine matter which really does form the accretion.

The sinking of the Fens is serious; we think that in about sixty years it will have reached such a stage that the scheme we are now adopting will no longer function. We shall then have either to take the channel round the silt land, and not allow any of the upland water to come into the fen at all, or to resort to pumping, or possibly to some other scheme. But we feel that in view of the heavy cost of the complete scheme it is inadvisable to expend capital before it becomes necessary to do so. The channel round the Fens is a natural extension of Mr. Griffith's scheme, because the portion below Denver is the same in both. Therefore, if my successors in sixty years' time are getting into difficulties they will be able to form, with complete satisfaction, the cut-off channel proposed by Sir Murdoch MacDonald.

I was interested to hear that Captain McClean considers the flow reasonable, because it is a vexed question what flood discharge one should design for. The figures we have used have been measured on the rivers at various stages, by a very ingenious system devised by Mr. Griffith, on which he has recently written a paper for the Institution of Civil Engineers. In the Eastern Catchment area the measurements were made where the river enters the Fens; and for the main river Ouse they were made at Bedford, and also at Brownshill Staunch just above Earith. I think the figures which are, on the whole, very consistent may be considered as reliable enough for design; and Sir Murdoch added 5 per cent. as a safety factor. Also in designing one does not design with banks to the level of the flood; one allows 2 or 3 feet, depending on the importance of the bank: so there again one has a safety margin.

With regard to the rate of discharge of the channel mentioned by Captain McClean, of course the rate of discharge is average discharge. On the tidal river the discharge varies from nothing up to many times the average. So in Mr. Griffith's scheme, the discharge down the cut-off channel from the South

Level is over 9000 cubic feet per second as a maximum, and it averages 5300. As to the barrage excluding tidal water, that brings back the proposal made in 1897 by some engineers at King's Lynn, Mr. Cocker and Mr. Stephenson. It was not regarded as satisfactory, and Sir Murdoch showed that the barrage would almost certainly result in silting below King's Lynn.

Secondly, there is not sufficient storage anywhere in the river above the barrage to take the river flow for the necessary period. So I think that the barrage proposed by Mr. Griffith is much the best: a scouring barrage. It holds back the tide until the level down stream is locked, and you open it and thereby increase the velocity.

The CHAIRMAN: I am sure you would all like me to assure Mr. Doran that his explanation of this interesting and most important problem has given all who previously did not know anything about the subject a clear picture. On your behalf I offer him our best and heartiest thanks.

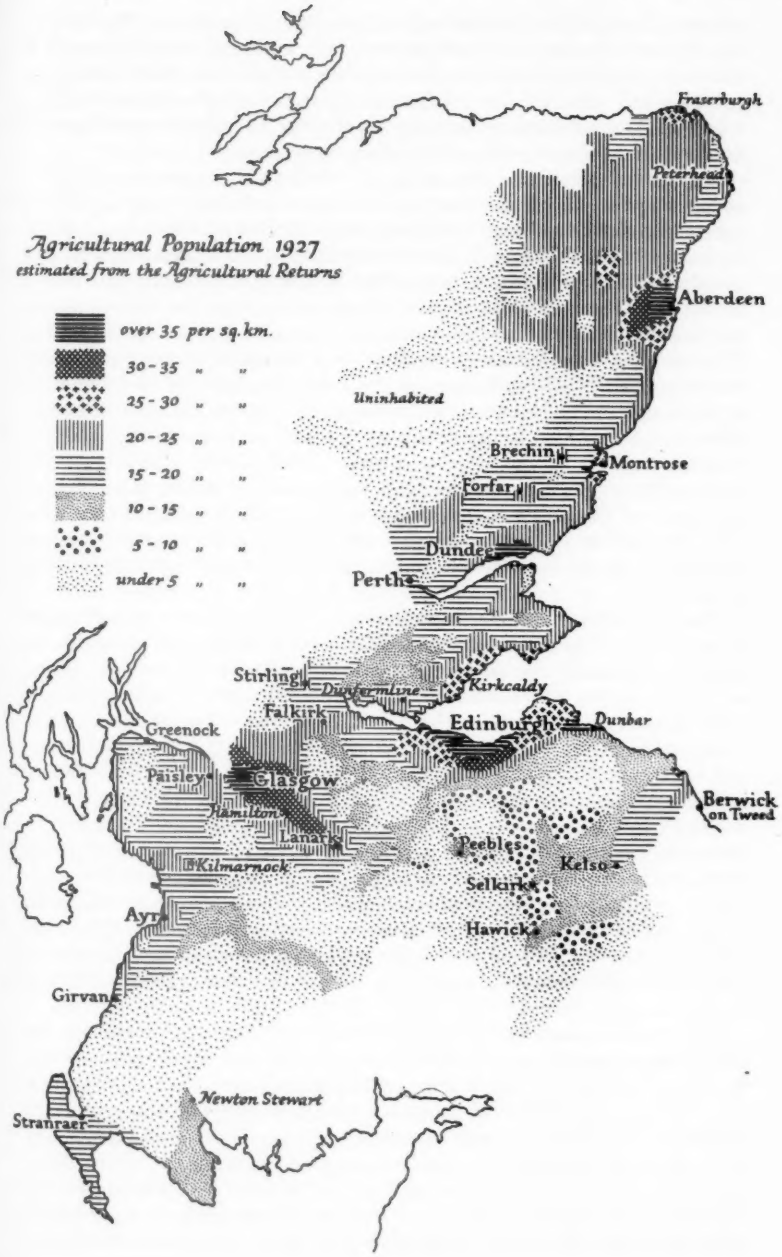
THE DENSITY OF AGRICULTURAL POPULATION IN SCOTLAND WITH ENGLISH AND EUROPEAN COMPARISONS

CATHERINE P. SNODGRASS

THE study of the density of agricultural population in different agricultural regions is one possessing both intrinsic interest and practical value. The question of the optimum distribution of population is very much in the air, especially in Britain which has become so highly and, according to many thinkers, dangerously urbanized. The time therefore seems appropriate for a survey of the existing agricultural population densities since such a survey should form an essential part of any national stock-taking of population distribution, and should be a necessary preliminary to any sound attempt to redistribute the population.

In Britain the problem of studying agricultural population densities is complicated by the absence of statistics of agricultural population for any administrative unit, and of the numbers occupied in agriculture for the smaller administrative units. The Scottish Census gives occupational figures only for counties and large burghs; the English for rural and urban districts as well, but the statistics of other agricultural phenomena are available only for counties and parishes. An investigator is thus thrown back on the laborious and not altogether satisfactory expedient of estimating the agricultural population. After several unsuccessful attempts to find a basis for estimating it from the total population of rural parishes given in the Census, I decided to use the Agricultural Returns to obtain the number of farmers and agricultural workers, and to multiply the sum of these by a factor to obtain an estimate of the population supported directly by agriculture.

In an article in the *Scottish Journal of Agriculture* 1924, on "Scottish Agriculture in the 1921 Census," J. M. Ramsay, Chief Statistician to the Department of Agriculture for Scotland, calculated that for Scotland as a whole this factor appeared to have the value 2. But an examination of the ratio of persons in industry to total population for various counties, burghs, and cities from the Census figures suggested that 2 was rather low; the city figure was approximately 2 and the cities showed a decided tendency to have a lower ratio than the counties with little urban population. I then tried a uniform figure of $2\frac{1}{4}$ for Scotland, this being the average of the factors for each county, but after sampling some examples in England, where the ratio is generally higher, approximately $2\frac{1}{2}$, and varied considerably from county to county, I decided in both countries to use the ratio for each county separately. Following Ramsay's practice I used 80 per cent. of the number of agricultural holdings to obtain the number of farmers. The estimates I eventually obtained therefore give the people actually working the land and their dependents, but do not specifically include certain classes whose livelihood is derived at least in part from the land—landowners and their dependents and employees. In so far as the owners are not gainfully employed however they and their dependents appear in the estimates since they contribute to raising the


Agricultural Population 1927
estimated from the Agricultural Returns
over 35 per sq. km.
30 - 35 " "
25 - 30 " "
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15 - 20 " "
10 - 15 " "
5 - 10 " "
under 5 " "
Fraserburgh
Peterhead
Aberdeen
Uninhabited
Brechin
Montrose
Forfar
Dundee
Perth
Stirling
Dunfermline
Kirkcaldy
Falkirk
Edinburgh
Dunbar
Greenock
Paisley
Glasgow
Hamilton
Lanark
Berwick on Tweed
Peebles
Kelso
Kilmarnock
Selkirk
Ayr
Hawick
Girvan
Newton Stewart
Stranraer

number of dependent persons and so the multiplying factor. The same is true of retired farmers and farm workers. The numbers occupied in agriculture were checked by counties with the Census and the error found was generally less than 2½ per cent., *i.e.* 1 in 40, and in many cases was less than 1 in 100. The estimated agricultural populations in 1927 for those parts of Scotland studied are shown on the accompanying map.

Agricultural population density is the result of a complexity of factors acting together and it is seldom easy to assess the weight of any individual one. In Scotland two broad influences stand out clearly at either end of the population scale. At the top there is the association of dense agricultural populations with proximity to large urban populations. This is clearly shown on the map where densities of over 35 per square kilometre (90 per square mile) surrounded by belts of 30–35 and 25–30 occur round the four big cities. The main reason for these high densities is the presence of market gardening, and where this is widespread, as on the raised beaches east of Edinburgh, densities up to 70 and even over 100 per square kilometre (180–260 per square mile) are found. Other factors are intensive potato production, large-scale pig feeding, particularly well developed west of Edinburgh, where it utilizes brewery by-products as well as hotel and restaurant waste, and intensive dairying, well illustrated round Aberdeen and in the Kirkcaldy-Leven area. The shape of the areas of relatively high density in the neighbourhood of cities shows the spread of those types of activity on to the most suitable land available.

The fact that near cities the average size of holding is generally small is also of importance. A comparison of region with region and of parishes within the same region shows that smaller farms tend in general to promote higher densities. In most of the suburban areas of high density the average size of holding is less than 50 acres and in none is it over 100. The presence of farms of several hundred acres employing many workers in the rhubarb-growing and market-gardening part of the Clyde valley just above Glasgow, and other evidence suggests however that small farms are a favourable though not a necessary factor in supporting large agricultural populations. The effect of proximity to consuming centres is seen on a lesser scale round most of the larger towns where the density is from 5 to 10 per square kilometre greater than is general in the surrounding region, *e.g.* Irvine, Stirling, Kirkcaldy, Forfar, Brechin, Peterhead, and Fraserburgh can be picked out on the map. The reasons are similar to those operating round the cities and include the tendency for the average size of holding to be smaller than in the surrounding region.

The broad influence so marked at the lower end of the scale is the association of low densities with sheep farming. In the hill sheep farms of the Southern Uplands and the south-east Highlands where the rough grazings carry at best one sheep to the acre, but more generally one sheep to 1½ or 2 acres, one shepherd can look after 500–600 ewes with occasionally a very little additional help. In those parts with pure hill farms containing many hundreds of acres of rough grazing and only a few acres of improved land, the agricultural population is generally 1–2 per square kilometre (3–5 per square mile). Further downstream, where the valley-floors are at lower levels and

winter fodder crops can be cultivated, cattle and sheep of heavier breeds are reared in the valleys in addition to sheep of the hardier types on the hills, and the population density rises to 4 or 5 per square kilometre (10–13 per square mile). It tends to be higher in Aberdeenshire with its valley cattle rearing than in the middle Tweed valley where this activity is not important.

But low densities are also associated with semi-arable sheep farming, *i.e.* arable farming organized partly for the production of crops for sale and partly for the provision of grass and fodder crops for the maintenance of ewe flocks of the heavier breeds and the rearing of lambs. In Scotland this is mainly located in the middle and lower Tweed basin and on the upper improved land in the Lothians east of the Pentlands. Population density varies from 9 to 14 per square kilometre (23–36 per square mile) in the less intensively cropped types in the higher and wetter parts, and is generally 15 or 16 per square kilometre (38–41 per square mile) in the lower Tweed valley. In the latter the average size of holding is 250 acres, fully 40 per cent. of the improved land is in cereals and roots (mostly turnips and swedes) and only 55 per cent. in grass, while the average number of sheep is 1500 per 1000 acres total area. In the former the farms are 300 acres in extent on the average, cereals and roots occupy less than 30 per cent. of the improved land, and grass approximately 70, while there are fully 1800 sheep per 1000 acres total area. Near the Berwickshire coast two small areas illustrate well some of the influences affecting density. There the agricultural population is from 7 to 10 per square kilometre (18–26 per square mile) above the normal in the lower Tweed basin, and the average size of holding is nearly 200 acres less. The more northerly of the two areas is one of cash cropping located on the small coastal lowland of Old Red Sandstone soils round Eyemouth, the more southerly includes a considerable number of Department of Agriculture Small-holdings. On the latter the general type of farming is the same as on the normal lower Tweed semi-arable sheep farms, but more attention is paid to poultry, pigs, and dairying.

The population densities of the other Scottish agricultural types studied range between 10 and 30 per square kilometre (26–77 per square mile). The average for Scotland as a whole is 18·4 per square kilometre of improved land (47 per square mile), and this is a low density compared with those of other European countries. The most populous type after the market gardening and intensive dairying and pig feeding round cities is fruit growing, supporting fully 30 in the middle Clyde valley, and barely 30 in the Blairgowrie and Montrose districts. This is followed by the intensive cash crop farming of lower Lothian and the East Neuk of Fife with approximately 26 persons per square kilometre (67 per square mile). The average size of farm is 120 acres. Eighty per cent. of the improved land is arable; 40 per cent. being in cereals, 10 per cent. in sale root crops, mainly potatoes, and only 25–30 per cent. in grass. Densities of 20–24 per square kilometre (51–61 per square mile) are found in the areas of cash crop farming of a slightly less intensive character, *i.e.* at intermediate elevations in the Lothians, in the remainder of the East Fife lowlands and the coastal belts in South Fife, Angus, and South Kincardine. Large areas of still less intensive cash cropping combined with some cattle and sheep rearing in North-West Fife, East Perthshire, and the

interior of Angus and South Kincardine have densities of only 16–17 per square kilometre (41–44 per square mile). Though in these areas 80 per cent. of the farmland is arable, rotations are longer and grass occupies from 45 to 50 per cent., and although cereals occupy from 30 to 35 per cent., wheat is less and barley much less than in coastal types. Sale roots account for 6–8 per cent. compared with fully 10; in consequence there is need for fewer winter stall-fed cattle.

In Aberdeenshire and North Kincardine, where farming is organized principally for the rearing and finishing of beef cattle, there is a remarkable uniformity of population density over a wide range of elevation, from sea-level to 900 feet, corresponding to the remarkable uniformity of agricultural practice. In spite of a shorter growing season and generally less fertile soils and lower crop yields than in the Central Lowlands, the north-east even in its high inland basins has an agricultural population of 21–23 per square kilometre (54–59 per square mile), a fairly high density for Scotland. This is associated with the prevalence of small farms, 50–80 acres, generally of the family type, a very high proportion of farm land under tillage (usually 90 per cent.) and worked on a fairly long rotation giving 50–60 per cent. in grass all told, and practically no cash crop except part of the oats. Pigs are moderately and poultry very important. The north-east thus illustrates the combined effect of small size of farm, high proportion of tilled land, and the keeping of large numbers of pigs and poultry in giving relatively high population densities. It suggests too that calf rearing is more favourable to high densities than sheep breeding. A study of variations within the region itself shows that where type of farming is fairly uniform the number of people supported is less where the proportion under tillage is below the average. In the coastal belt of heavy red boulder clay the population density falls to 16 per square kilometre (41 per square mile) except where counteracted by suburban influences.

In South-West Scotland the highest densities other than those of suburban and fruit-growing districts are found in the coastal lowland of Ayrshire, generally with 23–24 per square kilometre (60 per square mile). In the north and south this is almost entirely associated with early potato production on the raised beaches, in the centre with mixed farming in which second early potato production and dairying are specially important. The proportion of farmland devoted to potatoes is often greater than in lower East Lothian and cows are generally more numerous; on the other hand cereals only occupy half as great an area and two-thirds of the land is in grass compared with one-third in East Lothian. In lower Renfrewshire and in the middle Clyde basin beyond the incised valley an average density of 20 per square kilometre (51 per square mile) occurs in a region of mixed farming comprising some potato production, but with the main emphasis on dairying. A similar mixed type gives similar densities in a belt stretching from the middle Clyde basin across the south part of the Central Coalfield into South-West Fife. In these areas a smaller number of people are required to till the land than in the Ayrshire coastal lowland, but this is partly compensated by the greater number engaged in dairy work. In inland Ayrshire, upper Renfrewshire, and the higher farmland in middle Lanarkshire the density is generally 17 per

square kilometre (44 per square mile). This is a similar density to that found in the interior of Angus, but the type of farming is quite different. In these western districts 80–90 per cent. of the farmland is in grass, only 10–15 per cent. in oats and roots, but dairy cows are numerous, 200–250 per 1000 acres of farmland, and pigs and poultry important. In these areas there is much buying of winter fodder since the recent change from the summer production of butter and cheese to the sale of liquid milk all the year round.

The Rhinns of Galloway have similar densities, 15 per square kilometre in the lower and 19 in the higher parts. There cows are equally and pigs considerably more numerous, cheese is often made on the farm and more labour is required for cultivation, 80 per cent. being arable compared with 45 in central Ayrshire. On the other hand poultry are not nearly so important. The average size of farm is also greater, about 120 acres compared with 80–90 in most parts of Ayrshire and Renfrewshire. The Machars, with 12 per square kilometre (31 per square mile), have a density corresponding to the less intensive type of semi-arable sheep farming in Roxburghshire and Berwickshire. The average size of farm is 150 acres. Arable land occupies only 55 per cent., and rotation and permanent grass together 80 per cent. of the farmland. Pigs are much less and sheep much more numerous than in the Rhinns, and though the total number of cattle is only slightly less, there are 100 cows less per 1000 acres of farmland. This comparison suggests that cattle grazing tends to support low densities, a tendency clearly shown in West Rutland in the English Midlands.

South of the border certain regions were selected for purposes of comparison with those studied in Scotland—for dairying Cheshire and for arable and mixed farming several agricultural regions in eastern England, including the Yorkshire Wolds, the Holland division of Lincolnshire, central Norfolk, central Suffolk, the Norfolk and Suffolk Brecklands, and the eastern arable and western grass regions of Rutland. The average agricultural population density in England and Wales as a whole is 22·3 per square kilometre of improved land, *i.e.* 4 more than the Scottish average. Information concerning the farming practice in the regions considered was obtained from Maxton's 'Regional types of British agriculture,' supplemented in Rutland and Holland by the reports of the Land Utilisation Survey.

The association of large agricultural populations with market gardening and intensive root cropping is well brought out in Holland; that of low densities with sheep farming in the Yorkshire Wolds. The location of market gardening and intensive root crop cultivation in the Holland Division of Lincolnshire is not the result of proximity to consuming centres but of the presence of suitable physical conditions. This area has three times as great a proportion of its land in potatoes as the most intensive arable belt in Midlothian, and has in addition a considerable proportion producing vegetables for sale and fruit such as strawberries, apples, and plums. The average crop and grass area per holding is 44 acres, *i.e.* comparable in size to the holdings in the neighbourhood of the Scottish cities; 80 per cent. of this is arable and about 60 per cent. devoted to sale crops. With such intensive cultivation livestock, apart from winter stall-fed cattle, are of minor importance. It is therefore not surprising to find that Holland has an average density of 45 per square kilometre (115 per

square mile). Within the Holland Division itself agricultural population is least on the whole on the west and south margins where farms are above the average in size and the intensiveness of cropping generally below the average.

Near the other end of the scale the population of the Yorkshire Wolds is similar to that of the middle and lower Tweed basin, about 13 per square kilometre of farmland on the thinner chalky soils in the higher parts and 16 (41 per square mile) where the chalk is covered with glacial gravels and clays. In discussing Wold farming Maxton gives an illuminating example of the effects of mechanization on population. On one 750-acre farm the population was reduced from 16 to 5 per square kilometre by mechanization, *i.e.* from 41 to 13 per square mile.

In Rutland there are examples of several types of farming supporting low population densities. On the Lincoln limestones and Northampton sands in the east part of that county semi-arable sheep farming with winter folding on turnips and a considerable output of wheat and barley supports on an average 13 per square kilometre (33 per square mile) of crops and grass. On the heavy clays in the west the grazing of cattle and sheep on permanent pastures with some rearing and dairying where the pastures are not too rich is associated with an agricultural population of 10 per square kilometre of crops and grass (26 per square mile).

In England as in Scotland there is a wide divergence in population density between the market gardening and intensive root producing areas and the other regions studied. Cheshire with its intensive dairying and with two-thirds of its farmland in permanent grass and only one-fifth in crops supports on the average 28 per square kilometre of farmland (72 per square mile). This density is 10 more than that of the dairying region of inland central Ayrshire, which has a similar proportion in grass. The difference seems to be related to the smaller size of farm, 50 compared to fully 80 acres, the slightly greater potato production, the keeping of more cows and fewer other cattle, and generally of more than double the number of pigs. It can not be attributed to greater productivity since the yields of all common crops except rotation grass hay are lower in Cheshire.

The sharply contrasted central Suffolk region with its mixed farming and 70 per cent. of its farmland arable, supports a similar average density, 27–28 per square kilometre. This is comparable with the density in the Lothians just beyond the market gardening and suburban farming belt. In central Suffolk the production of grain and potatoes for sale is less but that of sugar beet is greater. The number of cattle is similar but that of sheep is half as much, while pigs and poultry are both four times as numerous. The average size of farm is 40 acres less and the yield of most crops lower than in the Lothians. Central Norfolk, with a similar proportion of arable land, has an average population density of 24 per square kilometre (61 per square mile). There the most important livestock enterprise is cattle feeding, and pigs are only two-thirds and poultry four-fifths as numerous as in central Suffolk. Crop yields are generally slightly higher. The poorer sandy Brecklands of West Norfolk and Suffolk with large tracts of heath and forest support only 17 per square kilometre of farmland (44 per square mile). The farms, which are mainly devoted to cash cropping (sugar beet, barley, and some

carrots) and sheep rearing, are large and the production and carrying capacity low.

On the Continent studies of agricultural population density have been made for Denmark by Professor Vahl, for Germany by Dr. Wm. Volz (incorporated in a study of population in general) and for Hungary by Dr. Péter Elek. I used these and the Deutsche Landwirtschafts-Atlas, the Polish Statistical Atlas, and population statistics to make some continental comparisons.

In Denmark the mean density of agricultural population is 39 per square kilometre of farmland. The islands and south-east Jutland have relatively high densities. There the more fertile soils and drier sunnier climate permit of a considerable amount of cash cropping as well as the intensive production of milk, bacon, and eggs characteristic of the country as a whole. Of the islands Lolland, which has still a large proportion of big farms, has the lowest density, 35 per square kilometre. The highest is found in the small island of Aero (45–50), where there are no large farms, and this is followed by Funen with 44, and Funen has a greater proportion of small farms than the other main islands. In the islands as a whole 90 per cent. of the farmland is arable, grass altogether occupies 30 per cent., grain 46 per cent. about half being wheat and barley for sale, sugar beet 5 per cent., and potatoes 2 per cent. On the moraines and fluvio-glacial sands of West and Central Jutland the soils are generally poorer and the density falls to 30 per square kilometre of farmland. Eighty per cent. is arable, but the crops cultivated, apart from some potatoes, are mainly oats, mixed grain, and root forage crops for the farm animals. Stock rearing is important as well as the production of milk, bacon, and eggs.

Professor Vahl finds there is a positive correlation between fertility and population density, and a close inverse relationship between the latter and size of farm. As in Britain, this is in large measure due to the more important part played by pigs and poultry on the small farms. The greater population density in Denmark as a whole appears to be due to the same factors, since the number of cows, pigs, and poultry is considerably greater than that general in Britain, and also to the consistently high proportion of arable land and the intensive cultivation. It is significant that in improving Danish agriculture and increasing the population maintained on the land the Government should have promoted the sub-division of large farms and that sheep should have progressively given place to cows and pigs until they have almost disappeared except on the heaths and sand dunes.

Relationships in several agricultural regions in Germany were studied, using Volz' map of agricultural population and the Landwirtschafts-Atlas for data concerning land use and livestock.

In the West Baltic coastlands of Germany soil conditions are similar to those of the Danish Islands and resemble those of central Suffolk and Norfolk. The population densities, 29–34 per square kilometre (74–87 per square mile) of farmland, are lower than those of the Danish Islands but slightly higher than those of central Suffolk. In this region farms are generally much larger than in the Danish Islands, many being over 1000 acres, only 75 per cent. of farmland is arable compared with 90, cereals are less important, and sugar beet negligible, while livestock are kept in much smaller numbers.

Compared with central Suffolk the percentage arable and the area of cereals are similar, sugar beet is less important, and potatoes slightly more so.

The good heavy loams and clays of the loess regions on the southern side of the North European Plain support about 50 persons per square kilometre of farmland. This density is comparable with that in the Holland division of Lincolnshire and the most densely peopled parts of the Danish Islands. These fertile regions are intensively farmed, 80–90 per cent. being arable, 50 per cent. in grain, fully half of which is wheat and barley, and 15 per cent. in cash roots (one-third sugar beet and two-thirds potatoes). On the whole vegetables and potatoes are not so important as in the Fens, but dairying and pig-keeping are much more so. The farms vary in size, some being large, so that this region corroborates the inference drawn from the Glasgow district that small farms are a favourable but not a necessary condition for maintaining large agricultural populations.

A comparison of densities on the loess lands and in the rye and potato belt north of them in Germany and East Poland gives a good idea of the contrasts between West and East Europe with respect to farming conditions and agricultural population densities. The loess region of East Galicia has 75–100 persons per square kilometre (192–256 per square mile) of farmland compared with 50 in the Leipzig embayment. The average size of holding is 12–18 acres; 80 per cent. of this is arable, 60 per cent. being in grain, fully 1 per cent. in sugar beet, and 13 per cent. in potatoes. Cattle are considerably and pigs much less numerous. The yield of cereals is about one-third of that in the Danish Islands and between one-third and a half of that in the loess regions of Germany; the yield of potatoes is four-fifths that of Central Germany. The food produced per unit of area is much less than in these two intensively farmed western regions, and yet the population is approximately double. The inference, which can be drawn from this comparison, that the standard of living is lower in East Europe, is a fact well known to geographers. The integration of stock and arable farming is not nearly so close as in West Europe. The use of artificial fertilisers and purchased animal foodstuffs is negligible and that of modern agricultural machinery is in its infancy.

A similar contrast is found within the less naturally fertile rye and potato belt. In Germany this carries on the average an agricultural population of about 30 per square kilometre of farmland, in Posen 50, and east of Warsaw 60. Posen has more cereals, sugar beet, and potatoes, but considerably fewer cattle and pigs than the German Plain west of it, while the region east of Warsaw has a similar proportion of cereals and potatoes to the latter but has still fewer livestock than Posen. Yields of potatoes there are similar to those in Posen, those of cereals about one-third less. As in the loess belt the food produced east of the Vistula is much less than in the corresponding region west of that river.

The densities in Hungary are also high compared with those of West Europe. In many parts both in East and West Hungary they exceed 50 per square kilometre of farmland and they are often over 80 (200 per square mile). Elek attributes the high densities in the North-East Alföld largely to the prolific population characteristic of East Europe; those on the south slopes of the Matra, where the density often exceeds 120 per square kilometre, partly

to that district having been a place of refuge during the Turkish invasions and partly to its suitability for vine growing and intensive agriculture. He finds a relatively low density in areas recently reclaimed from liability to flooding and in the dune areas only recently fixed by afforestation, and a high one in the south-east and south-west, and round Kecskemet where soil conditions favour intensive cultivation. Within the limits of size usual in the country he does not find any correlation between size of farm and density of population, but he notes that in North Transdanubia, where big proprietorships exceed 30 per cent., population density is particularly low. Elek's most divergent correlation, compared with correlations in the west, is that in the northern valleys, where density is normally high, it falls below normal in the vicinity of mines and factories. According to him this is due to the attraction these offer to the rural workpeople. This suggests that normally more people are supported on the farms than those really necessary to work the land and their immediate dependents.

It would seem from this cursory survey that there exist two types of high agricultural population density in Europe. One in the east associated with low productivity and a low standard of living, the other in the most highly developed regions of the west where physical and economic conditions favour the production of vegetables and sale root crops, or the very intensive production of milk, eggs, and bacon on highly cultivated small farms. In the east relatively high densities are associated with most favourable natural conditions or with historical circumstances leading to overcrowding in regions of refuge. In the west they are associated with small farms, and the intensive production of vegetables, fruit and root crops, dairy, pig, and poultry products. It is hopeful for the future maintenance or increase of agricultural population in the west that it is just these products which nutrition experts say are now particularly deficient among the urban populations there.

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THE STRENGTH OF THE EARTH

STRENGTH AND STRUCTURE OF THE EARTH. By R. A. DALY. *New York: Prentice-Hall*, 1940. 9×6 *inches;* x+434 *pages; maps and diagrams.* $3.50

THIS is a learned work. The early chapters read like a source-book on the figure of the earth and isostasy, with copious quotations from the original papers, many of them seldom or never mentioned in other works. The selection is such as to give a very full account of the technical methods as well as the results. The author is very critical, but some mis-statements have survived. The gal, instead of being defined as an acceleration of 1 cm. per sec. per sec., is defined in terms of the dyne; whereas the meaning of the dyne depends on that of the gal and not vice versa. In the long extracts from Bowie however gravity is given in dynes without reference to the mass acted on, and the author gives no warning against the confusion. He also appears to accept the possibility of determining whether compensation is local or regional by means of gravity observations alone. Meinesz and Bowie have both maintained this, Meinesz deciding that it is regional and Bowie that it is local; Daly agrees with Meinesz. It follows at once however from the principle of Green that local compensation at any depth is exactly equivalent in its effect on the external field to a certain regional compensation at any smaller depth. When Bowie found that the gravity anomalies were increased by assuming regional compensation he maintained the same depth; but that would be equivalent to using local compensation at a larger depth, and the anomalies were bound to be made larger because the depth of local compensation had already been chosen to make them as small as possible. Other grounds for a decision may exist, but analysis of gravity observations will not give any. I think that for presentation of results it is best to use local compensation, because the depth of the best local compensation affords an upper limit to that of any regional compensation, and if the true depth can be found in any other way the amount of regionality can be inferred; if we try to determine a regional compensation directly we are really trying to determine two unknowns from data that can only give one.

Daly argues again that the uniformity of mass per unit area used in discussions of isostasy is an approximation to uniformity of pressure over a spheroid within the asthenosphere. He disagrees with Hinks and Hunter, who have maintained that the word isostasy has been used in so many senses that it should be dropped. I am inclined to agree with him here, but I should advocate defining it better. We can define it to mean a state such that the stress below a certain level is hydrostatic, and that the stress-differences above that level are the minimum consistent with the surface inequalities. Apart from inequalities whose horizontal extent is small compared with the depth of compensation, this condition is sufficiently precise. But it does not give uniformity of pressure over spheroids below the level of compensation, and it does give uniformity of mass to a higher approximation. Thus when isostasy is defined in this way, which is clearly the suitable way if strength is to be discussed, uniformity of mass is a better approximation than uniformity of pressure and not an inferior substitute for it.

Daly is curiously worried about the term in $\sin^2 2\phi$ in the earth's figure. He says (p. 109) that a form for gravity containing only $\sin^2\phi$ would be exact if the sea-level figure of the earth were an exact ellipsoid of revolution. This is not so; the exact form is much more complicated. The point is that we cannot simultaneously express gravity and the radius vector exactly in the form $a+b\sin^2\phi$;

if either of them was expressible in this form there would be a term in $\sin^2 2\phi$ in the other, with a coefficient of order b^2/a. Further, for theoretical work it is convenient to use the geocentric latitude, but this differs from the observed or geographic latitude, and the transformation from either to the other brings in a term of this form. All these terms are too small to be found by analysis of observations, but have to be included for the sake of consistency in the theory. To choose a value for one fixes all the others, and this is done in the international formula so as to make the figure an exact ellipsoid. But it is merely a conventional choice of a standard of comparison and has no subtle physical meaning such as Daly tries to discover.

It is good to find in a work by a geologist a clear distinction between rigidity and strength, though this is marred later when rigidity is used to mean strength in quotations, without warning that this sense does not correspond to that defined earlier in the book. It is also good to find an explicit recognition that the ocean floors are stronger than the continents (p. 414). Professor Daly thereby places himself in opposition to the continental drift school.

The novelty of the book is in the interpretation of isostasy. Daly accepts the extreme form of it given in Nansen's papers on the Strandflat, and is prepared to entertain the idea of an asthenosphere with a fundamental strength much less than the gravity anomalies suggest, and even with none at all. I have discussed this in relation to Niskanen's work (*Geogr. J.* 95 (1940) 384), and most of what I say there is applicable to Daly's book. Daly accepts Heiskanen's triaxial figure and recognizes that it implies considerable stress-differences to a very great depth. But he revives Barrell's Centrosphere or central region of great strength [1] by introducing a Mesosphere between the asthenosphere and the central core. Daly takes this to be triaxial, the stresses being supported by its own strength, then its gravitational field makes the level surfaces outside it also triaxial, without the need for any strength above it. He thus divides the anomalies of gravity into short ones supported by the strength of the lithosphere; intermediate ones that throw stress-differences on the asthenosphere and are producing flow in it; and the Heiskanen longitude term, which indicates strength in the mesosphere. Daly is inclined to place the top of the mesosphere at a depth of 200–480 kilometres, the latter limit being at the 20° discontinuity of seismology. (Daly calls it the Jeffreys discontinuity, but if personal names are to be associated with it it should in fairness be the Neumann-Byerly-Lehmann-Jeffreys-Bullen discontinuity. Also Daly says that Bullen accepted my results about it, but this is only natural since he had an equal share in producing them.) He regards the asthenosphere as vitreous peridotite near the melting-point and the mesosphere as crystalline. There are several difficulties about such a structure. In the first place, the inequalities of gravity cannot be so simply classified. In a recent paper [2] (published since the book under review) I have rediscussed the data and failed to find any decisive evidence for the Heiskanen terms. Using as data the estimated means over 10° squares, there is a variation in excess of the error of sampling, and represented by a mean square variation of about 22 milligals. This represents the average departure from isostasy. But when allowance is made for the existence of this variation, and the fact that its distribution is unknown over the unsurveyed portion of the earth, it turns out that the data will not permit the separation of the low harmonics to such an extent that we can be reasonably sure of the sign of any one of them. There must be harmonics of degrees from 2 to 6, but we cannot determine them separately until

[1] I have always greatly admired Barrell's work, but have never understood him on this point.

[2] M.N.R.A.S. Geophysical Supp. 5 (1941) 1–22.

the gravity survey is much fuller. Now I estimate that the variation between 10° squares, if the loads were supported by the strength of the lithosphere, would require a strength about three times that of granite. They must therefore be supported either by the asthenosphere or the mesosphere, and in any case will involve considerable stress-differences within the former. Daly emphasizes the association of negative anomalies with rising land surface in the region affected by the last glaciation, but this association is far from perfect even there, and examination of many other regions would be needed to establish that it is anything but accidental. There is an abundance of information suitable for the purpose. I mention the doubt about the Heiskanen term chiefly because Daly often uses it where the anomalies in comparison with the International formula have the wrong sign for his theory, but take the right sign if Heiskanen's formula is used.

The temperatures used by Daly for the asthenosphere are of the order of 1400°. These are much higher than I got in 'The Earth,' but Bullard and his collaborators have given strong reason to suppose that even the latter are too high. However, to get the requisite distribution of strength Daly has to suppose cooling through some 500° since solidification in the mesosphere, while there has been hardly any change in the asthenosphere. This would be hard to explain on any theory of heat transfer. Again, the thermal changes would produce stresses in the mesosphere and presumably deep-focus earthquakes there; whereas, in spite of Daly's optimism, it is very hard to see how the stresses could accumulate in the weak asthenosphere. Thus with his structure we should expect abundant earthquakes in the top 60 kilometres, hardly any between there and, say, 480 kilometres, and a new set below that. The actual frequency falls off steadily with depth, and the level where they should recommence is nearly that where they practically stop.

Daly does suggest an alternative explanation of deep earthquakes, namely that foundered blocks of rock would change their state discontinuously under pressure. This is open to two objections. First, such changes for a given material would happen at a definite pressure and therefore at a definite depth; they would not explain a continuous distribution over a great range of depth. Secondly, they would be primarily changes of volume and not of shape, and the waves emitted would be mainly or entirely longitudinal, whereas the transverse ones are usually the larger.

He offers criticisms of a suggestion of mine, that the strength for some hundreds of kilometres below the upper layers is comparable with that of surface rocks, and that we need a completely new explanation of isostasy so far as it holds. My suggestion was that the regions where the gravity anomalies are of the order of 20 mgal. are those where the crust has been broken, and thereby weakened. I am not much impressed by most of his arguments, but one seems serious, namely that a deep fracture under high pressure would soon become a welded contact and the rocks would be as strong as before; compensation could not keep pace with denudation as well as it usually does. On the other hand Daly does nothing to remove the difficulty, pointed out also by Anderson and Kennedy, that if an ultrabasic asthenosphere is hot enough to be weak, the lithosphere in contact with it would be thoroughly liquid, since its melting-point is several hundred degrees lower. This argument is just as troublesome for Daly's theory as for others, indeed more so, since he is using higher temperatures, and my suggestion is the only one so far that attempts to meet it, however unsatisfactorily.

Meinesz's theory of the formation of a negative gravity strip is treated fully. I cannot follow his argument that it is easier to push the surface downwards

than upwards "because this bulge has to be pushed downwards against a density difference of about 0·6, while an outward bulge, that has to be pushed upwards, has a density of about 2·7." Unless the rocks develop a horizontal split and the top is to rise and leave a hole, we are dealing in either case with deformation of a complete sphere, and the work to be done against gravity and hydrostatic pressure together is the same. Meinesz thinks that the formation is a matter of elastic instability rather than fracture. Daly disagrees, and so do I. A floating rock layer, to give elastic instability before fracture, must not be more than a few metres thick. Meinesz thinks that if the layer is stratified this conclusion would be greatly modified, but it is a matter of energy, and if there was only one coherent layer in the lithosphere 20 metres in thickness it would be enough to prevent elastic instability.

The book is interesting reading. Though I do not think that the final conclusions about the extreme weakness and high temperature of the asthenosphere are tenable, a worthy effort is made to tackle difficult problems, and many arguments on the way need to be remembered. HAROLD JEFFREYS.

AGRICULTURE IN UGANDA

AGRICULTURE IN UGANDA. By The Staff of the Department of Agriculture, Uganda, editor J. D. TOTHILL. *Oxford: University Press* (*London: H. Milford*), 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xvi+552 *pages; illustrations, maps, and diagrams.* 20*s*

IN the masterly African Survey made by Lord Hailey's Committee and published by the Oxford University Press in 1938, a general account was given of the agriculture of the various regions, but it was necessarily brief. The expert who requires more detail has to consult the reports of the different colonies and dependencies which are not easily accessible except in a few of the larger libraries and at Rothamsted. In any case many of these reports are of an interim nature and require considerable time for perusal and assimilation before a full story can be worked out.

The staff of the Department of Agriculture of Uganda have prepared a connected account of agricultural developments in that colony, and this is now issued as a very attractive volume under the capable editorship of Dr. Tothill. Modestly enough no history of the department is given, though in a subsequent issue this might be added; there is however a chapter on the Experiment Stations and Farms.

Remarkable progress has been made since the Botanic Garden was first established in 1898 under A. Whyte. The development has been not only in details but in direction also. In the early days the aim was to contribute to world markets and in return to receive the benefits which European civilization was supposed to confer; agricultural experts were therefore largely concerned with finding what economic crops could advantageously be grown in the colony. Cotton, coffee, cacao, sisal, rubber, and others were tried, and gradually a number emerged as being suitable for planting on a large scale. But as time went on two other purposes came into prominence: the better feeding of the natives, and the conservation of the soil. To-day therefore the problems are more complex and more diversified than they were, in consonance with the wider view now held of our responsibilities to our colonial possessions. The British Empire

differs fundamentally in this respect from the Axis powers: their purpose is exploitation for the benefit of the home country—the so-called Metropolitan—while ours is the development and enrichment of the colony itself for the benefit of its inhabitants. The benefit to the home country is incidental, but is nevertheless very real.

The book opens with an interesting account of the geography and the climate of Uganda and of its native agriculture, land tenure, etc. This is illustrated with maps, diagrams, and tabular matter, and by a number of excellent photographs. It is characteristic of the modern view of colonial administration that the account begins with native food crops, the chief of which are bananas (by a long way the most important), *Eleusine* (877,000 acres in 1936 as compared with 293,404 in 1916), sweet potatoes, cassava (296,294 acres in 1936, but only 6169 in 1916), beans, sorghum, and others. A sufficient account is given of each of them: their cultivation, varieties, diseases and pests, methods of control; the accounts are adequate and never so long as to be tedious. Clearly the staff have taken this work on native food crops seriously and have furnished much effective help to the cultivator.

Then come the cash crops: the most important is cotton, which has increased from 92,127 acres in 1916 to 1,487,000 acres in 1936. There is no evidence of the existence of true native cotton, though there has been some cultivation for a long time; most of the old sorts go back to *Gossypium brasiliense* almost certainly introduced by the Arabs. After the period of tests and experimentation Uganda settled down to a group of varieties intermediate between Egyptian and American cotton; formerly it nearly all came to this country for mixing with medium staple cotton, but increasing quantities have gone to India where it is spun pure. Uganda competes with the Sudan for the second place among the cotton-growing countries of the Empire, India having the first. But the organization is very different from that in the Sudan: the crop is not irrigated, and therefore there is no need for the unified methods of cultivation there adopted; instead it is entirely native grown. Next in importance comes coffee, which Mr. Thomas thinks must be indigenous; *Robusta* coffee has been so long known that it comes into the ritual ceremonies. Sugar also is grown, but on estates: it is estimated that yields of 40 tons per acre of cane may be expected, and that 1 ton of white sugar may be obtained from 11 or 12 tons of cane. The standard estate variety is an American sort POJ 2725, but numerous others have been tested. Tobacco, like cotton, is a native and not an estate crop. The plantation crops include cacao, rubber, tea, oil-yielding plants, and drugs. Considerable interest is taken in tea; under the Tea Restriction Scheme only 2000 acres were allotted for planting during five years, but applications exceeded 8000 acres.

Quinine deserves special attention. The trees grow well enough in the regions selected, and the British Empire is a large consumer but only a small producer. In peace time the Dutch East Indies had almost a monopoly of the natural product and Germany of the synthetic compounds; our own production was not developed. Mr. Thomas says: "If present prices are maintained it is probable that the crop will prove profitable in Uganda, but the market is so uncertain that large-scale planting cannot be recommended." It seems an unwise policy that the Empire should leave itself unsupplied with so essential a commodity, and some safeguarding steps should be adopted.

It is always necessary to pay the price of agricultural development, something is gained and something is lost. The native system prior to British administration was very simple: cultivation was for food production only, and no crops were grown for export. Wars, diseases, and famines kept down the population

both human and animal, so that the pressure on the land was not great. After a few years of cultivation the land was left to cover itself again with native vegetation and a new area was broken up. Soil exhaustion and soil erosion had hardly begun, and although some of the soil organic matter was destroyed during the cultivation there was some mulching with leaves and other vegetable matter. Had the population remained low the system could have gone on indefinitely.

But with the introduction of British rule the factors keeping down population were removed and so the numbers increased, making greater demands on the land. Further, new standards of living came in; the natives could no longer be kept innocent of all knowledge of money and of what it would buy; moreover social services were introduced, and had to be paid for by taxation, which is much more easily collected in money than in kind. Cash crops therefore became necessary as well as food crops. In consequence the area under cultivation had to be greatly increased so that the old "shifting" system was impossible. Before long soil erosion began to set in; happily it is not very widespread. Mr. W. S. Martin points out that neither gully erosion nor wind erosion are common except locally: sheet erosion is the more usual form; this is unfortunately difficult to recognize in its early stages when control would be most easy, and it is very destructive of fertility. The surest remedy is to rest the soil in grass if this can be done.

Fortunately the problem was recognized and the treatment studied before matters had gone too far. A wide educational campaign was undertaken and considerable publicity was given throughout Africa and beyond. Our honesty in this matter was misunderstood by some of the foreign agricultural experts, several of whom had on occasion assured me that had their countries been in charge the trouble would never have arisen: more probably it would never have been admitted. Then came the war and all the upsetting that it involved: loss of staff which was bad, and complete re-examination of the cropping programme with a view of ensuring maximum home production of food, which opened up possibilities of improvement. Good may yet come out of this great evil if the revised schemes are based on sound principles of soil conservation. The present tendency to a larger and more varied dietary fits in well with this, for it is easier to work out a soil conservation policy with a variety of crops than with a single one.

A sound live-stock policy is however indispensable, and that presents grave difficulties in the large parts of Africa, where live stock are not simply sources of income but are marks of wealth and social standing. An English farmer looking through this book would be astonished to find only a short section on grazing and none on animal husbandry. Live stock have not yet become intimately blended with crop production as in England, and yet so far as is known this infusion is the surest way of maintaining soil fertility as a permanent asset. Live stock in Africa come rather under the Veterinary than under the Agricultural departments, and some reorganization will no doubt be needed to bring them into their proper relationship to the cropping scheme.

If a second edition is called for it would be an advantage to give a short statistical summary by way of appendix, to include more references to the annual reports and other sources of fuller information, and to give the names of the authors of the different chapters as well as their titles in the list of contents. These however are only minor details. It is to be hoped that other departments in Africa are preparing similar reports for publication in due course, for it is certain that we shall be called upon to render an account of the stewardship of our African colonies, and we have a good account if only we present it well.

E. J. RUSSELL

THE UKRAINE

THE UKRAINE: a history. By W. E. D. ALLEN. *Cambridge: University Press*, 1940. 9×5½ *inches;* xvi+404 *pages; maps.* 21*s*

MR. ALLEN has not only written with admirable objectivity on a subject which has hitherto almost always been treated in a very different spirit by Ukrainian, Polish, and Russian authors, but he has also succeeded in bringing the Ukraine into relation with its various neighbours. He has shown how not only Poland and Muscovy but also the Ottoman Empire impinged on it at different times. His book will be of the greatest use to all who have to deal with the Ukrainian question. Had such a work existed twenty years ago, the writer of this review would have been spared much laborious delving in histories which ought to have taken the Ukraine into serious consideration but in fact threw on it no real light either historical or geographical.

Perhaps the most important event in the history of the Ukraine in the last three hundred years is the agreement of Pereyaslavl in 1653–54 by which Bohdan Khmelnytsky and the Cossack elders put their country under the protection of Tsar Aleksey Mikhailovich. At the final ceremony in the cathedral of Pereyaslavl, Khmelnytsky asked Buturlin, the imperial envoy, to swear in the name of the Tsar that he would defend the Cossacks against the King of Poland and respect their liberties. Buturlin retorted that the word of the Tsar, as autocrat, was sufficient and could not be doubted. It is not unfair to draw a parallel between the Cossack leaders of the mid-seventeenth century and the Ukrainian politicians now living under the German occupation in such purely Polish towns as Warsaw and Cracow. Khmelnytsky did not believe in the good faith of the Tsar whom none the less he hoped to make use of in order to establish Ukrainian independence of Poland. The Ukrainian politicians from Eastern Galicia, who have found it more prudent to escape from the Russian into the German occupation of Poland, probably do not put much confidence in the German intentions as regards the Ukraine. In the past one of the most important of them always maintained that Germany as a Power was constitutionally unable to respect the individuality of any Slav race with which it came into close contact. The trouble is that the less politically experienced races in eastern Europe, among whom, without disrespect or ill will be it said, are the Ukrainians, often have too much confidence in their own cunning and are apt to believe that they can outwit the Greater Powers. Sometimes too they seem to be inspired by a sort of inferiority complex which makes them believe that in the confusion of the judgment day they will be overlooked and allowed to get away with at any rate part of their spoils. There is much evidence that during the present war the Ukrainians of Eastern Galicia have gone on the assumption that the Soviet rule will not last long there: for the time being however use should be made of it to clear the country of Poles and Polish culture.

Mr. Allen's account of the growth of the Ukrainian movement in former Austrian Poland before the World War is admirable, and it is to be regretted that he has not found it possible to deal with Polish–Ukrainian relations since 1919 at greater length than in a four-page note to Chapter VI. This note contains much valuable information but in too condensed a form. In consequence some of the statements made, for instance, concerning the closing of non-Roman Catholic churches in parts of Poland inhabited largely by Ukrainians, are unduly generalized. Incidentally it is doubtful whether even after Marshal Pilsudski's death, when the administration in Poland passed too much into the hands of the military, any *Uniate* churches were closed or affected to the Latin rite. The

closing of Orthodox churches in the Kholm region in 1938 by the military authorities was strongly reprobated by Polish public opinion, not least of all by several of the Roman Catholic bishops. Some confusion is introduced into Mr. Allen's account of this period by his refusal to use the word Ruthenian, which is certainly a convenient label for those persons who use the language now usually called Ukrainian but do not call themselves Ukrainians. In Eastern Galicia these people usually called themselves Old Ruthenes. Mr. Allen calls them Russians. It is doubtful whether even before 1914 they would have accepted that style, though they were undoubtedly disposed to regard themselves as poor cousins of the Great Russians. In the last twenty years they have certainly considered themselves as distinct from Russians in the ordinary sense of the word. The Poles called such people *Rusini*, which is usually Englished as Ruthenians, and not *Rosjanie*, or Russians. On p. 339 Mr. Allen speaks of "the Polish census of 1939," which "admitted only 1,600,000 Ukrainians in Eastern Galicia, while the population of Russian origin in other regions of Poland was not allowed to be even in part Ukrainian." The present reviewer does not know of any Polish census held in 1939. The census of 1931 divided the population up according to mother-tongue instead of race: the criterion adopted in the 1921 census. According to the 1931 census, besides about 2,800,000 persons speaking either Ukrainian or Ruthenian as their mother-tongue in the East Galician voivodeships of Lwów, Tarnopol, and Stanislawów as against about 2,900,000 speaking Polish as their mother-tongue, there were 1,426,000 speakers of Ukrainian and Ruthenian in the voivodeship of Volhynia, besides 53,000 in that of Polesia, where however the speakers of White Russian were more numerous. It must of course be remembered that the Lwów voivodeship includes several purely Polish *powiaty* to the west of the San river.

There is one gap in Mr. Allen's generally admirable book: he hardly says a word about modern Ukrainian literature and he does not even mention the name of Ivan Franko, whose verses reveal a personality less amiable perhaps but infinitely more forcible than that of Shevchenko. The poetry of Franko, who died during the World War, may be a little out of fashion for the time being but it is the interesting expression of a very vigorous personality, whose name has been substituted by the Soviet authorities for that of a Polish King in the style of the Lwów University. But perhaps the most remarkable writer yet produced by his race is Stefanik, an East Galician Ukrainian of peasant stock who came under the influence of the Mloda Polska group of Polish writers at Cracow University, returned to his little property in Eastern Galicia, and died a few years ago. His collection of short sketches of peasant life entitled *Zemla* has qualities of the highest art. It is interesting to note that according to Bohdan Lepke, one of the best Ukrainian writers of the generation which is now passing away, the Polish landowners in the Ukraine contributed greatly to the development of the Ukrainian literary language. Not only did they talk Ukrainian with the peasants on their estates as a matter of course, but they were at pains to speak it well, and therein, according to M. Lepke, they differed entirely from the Great Russians who owned estates in the Ukraine.

REVIEWS

EUROPE

PREHISTORIC ENGLAND. By GRAHAME CLARK, F.S.A. *London: Batsford*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii + 120 *pages;* 110 *plates*, 31 *text-figures.* 8*s* 6*d*

This most recent addition to Messrs. Batsford's deservedly popular "British Heritage" series is a notable book, for it has all the virtues of its fellows, attractive appearance, copious illustration, and readability, and yet it breaks new ground. Topographical works in praise of the English scene are legion, and many of them produce, as they are intended to do, a nostalgic desire for an enjoyment which we must all perforce forego in war-time. This book has achieved both this and a wider purpose, for it forms the best introduction to British pre-history yet written for the non-expert. Dr. Grahame Clark is an acknowledged master of his subject, in which greater progress has been made in the last decade than in any other branch of archaeology. His wide experience as a field-worker and as a teacher is here effectively used to produce, within the narrow compass of a single volume of one hundred and twenty pages, a synthesis of the mass of diverse and scattered material which has resulted from the widespread and intensive scientific excavation of recent years. Wisely eschewing chronological treatment he has concentrated on the daily life of those, our ancestors, who built and used our most ancient monuments. The Food Quest, Dwellings, Handicrafts, Mining and Trade, Communications, Hill-forts, Burial, and Sacred Sites thus form the divisions of his subject. By discriminating selection and wise emphasis he provides an accurate, informative, and lucid account in some dozen pages of each of these aspects of the life of ancient man from the Upper Paleolithic to the Belgic period. Possibly the reader not acquainted with our Museum collections may find difficulty in such a packed chapter as that on Handicrafts, where the sheer profusion and diversity of the archaeological material defy brief treatment, but no such doubt could be felt about such chapters as those on Mining and Trade or Hill-forts, where inclusion of the very latest field-work gives the book a special appeal to the archaeologist as well as to the lover of the British countryside. In the belief that a second edition of what can only be regarded as an interim report will soon be called for, it should be noted that the alleged currency-bars found at Wayland's Smithy (p. 45) have unhappily proved to be modern, while to speak of a Roman lead pig as inscribed "Claudius 49 A.D." (p. 64) is misleading to say the least of it. The simple system of numbered references to the hundred and ten splendid photographs might with profit be extended also to the numerous and admirable text-figures. The wide use of aerial photography, which has become a recognized tool in the hands of the modern archaeologist, deserves special commendation.

P. C.

ASIA

SOCIAL AND ECONOMIC ORGANIZATION OF THE ROWANDUZ Kurds. By E. R. LEACH. (London School of Economics: Monographs on social anthropology No. 3.) *London: Percy Lund, Humphries and Co.*, 1940. $9\frac{1}{2} \times 7$ *inches;* iv + 82 *pages; illustrations and diagrams.* 5*s*

The north-easternmost corner of Iraq, where the territory of this kingdom forms a wedge between Turkey and Iran, has been recently described in two good books by W. R. Hay and A. M. Hamilton, but Mr. Leach, while limiting his

scope, carries the investigation in many regards further than his predecessors. He eliminates the casual and the picturesque and concentrates on the general foundations of Kurdish polity, or on such isolated facts as explain the interplay of economic and social factors. The author's special training as a sociologist enables him to explain the structure of the clans, the problems of land tenure, the factors affecting the tribal cohesion or impeding the economic evolution of the region. In this regard his book forms a parallel to Professor Eghiazarov's important essays on the Erivan Kurds and the recent French studies by Rondot and Lescot on the Kurds of Upper Mesopotamia.

The weak point of the book is the author's indifference to history (p. 6, on Rowanduz having been a part of the Hittite empire) and to the general studies of the Kurds, outside the particular field of his investigation. The presentation of the subject is rather static. Instead of some African parallels, one would expect more references to such books as Rich's 'Residence in Kurdistan.' The author might have found in Rich some hints on the pre-Kurdish populations (Guran, etc.) in Kurdistan. Such ancient residents may have transmitted their agricultural habits to the Kurds and contributed to the settlement of a good number of tribes. The author (p. 23) rejects as a fantasy the idea that the *taifas* "represent the original owners of the soil," and the *Aghas* are "the conquering overlords," but this hypothesis is not at all irrelevant. It would be interesting to assess the influence on the Kurds of Persian culture, and of the Ottoman institutions in more detail than it is done on p. 10. Before the Ottomans, the Turcomans and, before the latter, the Mongols had left their imprint on Kurdish life. The tribe of Surchi (the drivers) may have kept its professional name since the days of the ilkhans. The Mukri tribe across the Persian frontier has a definitely Central Asian name.

The author himself admits that some points need a further investigation. Among them is the important problem of nomads periodically visiting the territory of Rowanduz. As Mr. Leach announces his intention to revisit the area we may confidently wait for the further observations of this keen observer.

V. M.

THE RUGGED FLANKS OF CAUCASUS. By JOHN F. BADDELEY. 2 vols. *Oxford: University Press* (*London: Humphrey Milford*), 1940. 11½×8 *inches;* xvi+272; x+318 *pages; maps and plates.* £6 6*s*

These sumptuous volumes, remarkable alike for their fine appearance and for the solid value of their contents, deserve more critical and extended notice than is possible in these times, when a really competent reviewer would be hard to find. But their very importance forbids delay in giving them at least a preliminary notice in the form of a general summary of their subject-matter and of the circumstances to which they owe their origin. From quite early days, in the eighties of last century, the Caucasus began to have a strong attraction for Baddeley, and he returned many times to the scene of his early travels, traversing the outer slopes and valleys of the range in a network of routes, and with the true ardour of a scholar studying the whole relevant literature, Russian and other, which gave him an intensive knowledge unrivalled, it is safe to say, in this country at least. Apart from special appendices, the work is throughout in narrative form, describing the several journeys in chronological order, but the wealth of explanatory notes, and copious references to the work of other travellers and historians, give it a value much above that derived solely from the personal observation of the most observant traveller, which Baddeley certainly was. It is based on carefully kept diaries, so that the delay in publication has been less serious than if memory alone had been drawn upon.

A rapid journey to Ekaterinodar (now Krasnodar) and back in 1879 gave Baddeley his first introduction to the Caucasus region, but not till 1888, when representing the *Standard* during the visit of the Emperor Alexander III to this part of his dominions, did he see the central part of the range, which he crossed by the Georgian road. The spell of the mountains under which he then fell determined him to return to them at the earliest opportunity, but this did not occur till the 'nineties, when he made various journeys as representative of business concerns, principally in relation to oil, and in the north-eastern section. In these and subsequent journeys he had the valuable help of an Ossetine named Urusbi, who in course of time came to be regarded as a friend, rather than a servant and guide. In his company, in 1898, he traversed the Ardon valley by the Mamisson road, crossing the main range by the similarly named pass to Kutais. Next year he made a spring traverse of the range from Vladikavkaz to Tiflis *en route* for the Baku region with a view to prospecting for oil. The same year's journeys included a trip to Saniba, in the valley of a stream descending north from Kazbek. More important still were the journeys carried out in 1901, still chiefly in the eastern part of the range. They included an expedition to Ami, on one of the head-streams of the Argun; a circular tour round Kazbek by passes of 10,000 feet and more; and visits to the primitive Chechen tribes in their mountain fastnesses on the northern flanks of the range south-east of Vladikavkaz. Three of these tribes—the Galgais or Mountain Ingushi, the Khevsurs, and the Ingushi proper—are dealt with in the last three chapters of vol. I, which give a valuable insight into their customs and mode of life. Among the Chechen tribes brigandage is so rife as to be the very breath of life with them, though less to be feared in their mountain homes than it is nearer civilization. A plan to cross the range through the country of the Pshavs and Tushins had to be dropped. Later in the autumn of 1901 Baddeley seized the chance of another visit to Daghestan, which, though occupying only two or three weeks, is described in detail in the first four chapters of vol. II. As usual they are packed with notes on matters of interest derived in part from an exhaustive study of other authorities.

So far Baddeley's travels had been concerned chiefly with the eastern Caucasus on the northern side of the range. In 1902 he gave equal attention to the northern flanks farther west, in Ossetia, Digoria, and Balkharia, beginning with a visit to the scene of the glacier-burst in the valley of the Ganal-don, a small western tributary of the Terek, the results of which he described at the time in a letter to the *Times*. Later, after joining and leaving the Mamisson road, he went west into the upper valleys of the Urukh and East and West Cherek, traversing on the way the Astuli pass (10,857 feet). Mountain Digoria, the first district visited, is a tract of country along the northern versant of the main range, occupying a schistose belt between the Jurassic limestones to the north and the granite to the south, and presenting some remarkable features. Reached alike from north and south by high passes only (all glacier-filled to the south), for the gorge of the Urukh on the north is quite impassable, its consequent seclusion lends it much interest, as is well brought out in chapter XIX. In Balkharia somewhat more advanced conditions obtained. The turning-point here was the village of Chegem, at the mouth of the wonderful gorge of the Djilki-su, of which Plate XIII in vol. II gives a striking picture. As in many other localities, Baddeley heard from a village ancient a legend concerning this gorge, which he tentatively suggests may have a possible connection with the classical one of Andromeda, as it speaks of the rescue of a maiden from a monster by a bold hunter. This would be on a par with the association of other classical myths with this part of the world.

In accord with the title of the work, Baddeley's concern was rather with the flanks than with the higher snows of the range, for unlike Freshfield and others, he was not primarily an Alpinist. But the routes followed called for all the intrepidity of a mountaineer, and some of his rides over the roughest mountain tracks involved many risks to life and limb. The greater part of the journeys were made on horseback, and his long apprenticeship to this mode of travel stood him in good stead. Another advantage was his wise habit of accommodating himself as far as possible to native ways, particularly in the matter of dress, by which he escaped undue attention as a foreigner. But the work owes no less to his scholarly research into other literature, his interests embracing the most varied subjects from botany and ornithology to ethnology and folk-lore, so that all classes of readers are well provided for. His perseverance in tracking down the correct answers to doubtful questions (such for example as the exact height of a mountain pass) was untiring, and the casual reader would have no idea of the labour thus involved.

The narrative portion is followed by appendices dealing with special subjects of a more or less controversial nature, that of most general interest, perhaps, being the one dealing with the route of the ten thousand Greeks in the part of their retreat nearest the Caucasus. The divergent views of four recent students are summarized and illustrated by a clear sketch-map. A valuable bibliography follows, and the full and systematic index bears the impress of care and conscientious labour which characterized all Baddeley's output. A useful feature (which might have been extended with advantage to the chapter headings) is the reference, under the more important place-names, to the map or maps to be consulted for each.

As was said at the outset, the outward appearance of the volumes is worthy of their subject-matter, so that from both points of view the work must take an outstanding place in the literature of travel. Paper and printing are excellent; the admirable plates are drawn by the author from photographs by an interesting method which will be the subject of a separate note. The maps are clear and include general maps of the Eastern and Western Caucasus with larger-scale sketch-maps of special sections of the routes, as well as a bird's-eye view of the general aspect of the whole range. The last is repeated in the two volumes, as are also the tables of contents, plates, and maps, by which constant reference from one volume to another is avoided.

Our satisfaction that such valuable material should at last be given to the world is tempered by regret that the author did not live to enjoy the final fruits of so many years' labour. E. H.

CONTRIBUTION TO THE ANTHROPOLOGY OF IRAN. By HENRY FIELD. Field Museum of Natural History: Anthropological Series. Vol. 29. *Chicago*, 1939. 2 volumes. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* 706 *pages; plates and folding maps*

The kernel of these two weighty volumes is the examination and manipulation of the figures obtained by measuring and observing two hundred and ninety-nine men mainly from four localities in Iran, to determine the racial types represented by the present-day population of Iran. This occupies about two hundred and fifty of the seven hundred and six pages: it is preceded by two hundred and fifty pages of prolegomena, including excerpts from writers of all periods relating to the inhabitants of Iran, descriptive notes on the physical character of the provinces, and annotated lists of tribes. Chapter five, "The physical anthropology of Iran," is followed by appendices, glossary, bibliography, etc., and one hundred and forty-four plates, some of scenery, the rest full-face and profile portraits of about one hundred and ninety of the individuals

studied. These portraits are satisfactory for their purpose, and in the conditions in which they were taken reflect credit on Dr. Field's companion, Mr. R. A. Martin, who acted as photographer. Dr. Field collected his data in August and September 1934, partly from material available in Baghdad and partly during a brief visit to Iran. The groups measured were Jews of Isfahan, perhaps established there since the third century A.D., natives of Yezd i Khast and Kinareh, and Lurs of Pusht i Kuh.

For each group in turn the data, classified and worked out in percentages, are presented with explanations and comments. The data comprise morphological characters, anthropometric measurements, and photographs. For the Isfahan Jews comparative data are given relating to Jews in south-west Asia and the Caucasus. For the other three groups an attempt is made to analyse each into different racial types, pure and mixed, such as a coarse Mediterranean type, Irano-Mediterranean, Hamitic, etc. Having considered the individual differences between the characters of the four groups, the author concludes that "they must be considered as anthropometrically distinct populations."

The author next sets himself the task of analysing "the constituent elements in the population based on the 299 individuals measured in Iran in 1934." It is impossible here to follow all the intricate processes to which the data are submitted, and those interested must refer to these volumes. In a final section Dr. Field gives a summary of twelve pages or so, which recapitulates and augments the earlier arguments. He concludes that "the basic elements of the Iran population which I studied are Mediterranean, although they show considerable variation and divergence. There are two types of Iranian Plateau dolichocephals, one straight-nosed, the other with large convex noses. The former are probably connected with the Beduins of North Arabia, the latter appear to have developed on the Iranian plateau." This "Iranian plateau race" he claims to be "a new fundamental division of the White race. . . . This new racial type now for the first time takes its place beside the long accepted Nordic, Mediterranean, and Alpine races."

It is a little surprising to a layman to find that so lofty an edifice can be built on so narrow a foundation, many of whose constituents would to him be suspect. No doubt a racial type is essentially a lifeless abstraction which bears no vital relationship to the so-called "races" and the nations of the present day. It is perhaps worth while however to note to how great an extent the author's deductions rest on his records of Isfahan Jews. Seventeen men, about 24 per cent. of the individuals placed in the Iranian plateau race, were Jews. One may ask what are these seventeen Jews: if Jews, by what process did they acquire the characteristics of this race; if Iranians, how did their forebears come to be incorporated into the Jewish community? These are perhaps idle questions: if there are Jews who show certain racial traits not shared by Jews elsewhere, that fact is presumably all that matters. D. L.

THE OTHER SIDE OF THE JORDAN. By NELSON GLUECK. *New Haven, Connecticut: American Schools of Oriental Research*, 1940. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* xviii+208 *pages; illustrations and sketch-maps.* $2.50

THE STORY OF JERICHO. By JOHN GARSTANG and J. B. E. GARSTANG. *London: Hodder and Stoughton*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xv+200 *pages; illustrations, diagrams, and end-paper maps.* 8*s* 6*d*

Both these books are by distinguished archaeologists. Addressed to the general reader, they are attempts to place a wider circle in possession of new discoveries which have already appeared in archaeological publications. The first is based on a series of lectures recently delivered in America to describe the explorations

in Transjordan which the indefatigable author has carried out over a number of years as Director of the American School of Oriental Research in Jerusalem; the second is a popular account of excavations conducted at Jericho on behalf of Sir Charles Marston and others under the aegis of the Liverpool Institute of Archaeology. Both books, the former in particular, contain new historico-geographical data though their matter is of primary interest to archaeologists and Biblical students: the latter will note that the writers differ widely in their dating of Joshua and the wanderings of the Israelites, Professor Garstang being the more revolutionary.

Professor Glueck's researches were of the nature of archaeological surface surveys. From the air, by car, by camel, and on foot, he covered an enormous area stretching from the Gulf of 'Aqaba in the south to the Wadi Zerqa, the ancient Jabbok, in the north, and embracing the old lands of Edom, Moab, and parts of Ammon and Gilead. He has had many predecessors, but they were mainly concerned with the more impressive remains which have survived, the dolmens and round towers in the north, and the ruined cities, Roman and Nabataean, both north and south, whereas his work has been largely concentrated on places which have been overlooked by earlier travellers because the only signs of antiquity are the masses of potsherds which litter the ground. The author is a specialist in ceramics, and it is an easy matter for such to distinguish the pottery of the Early Bronze Age from that of the Early Iron, and both these from later Roman, Nabataean, and Medieval wares. Hundreds of ancient sites which were previously unknown have been identified and dated within approximate limits on this evidence, and much light has consequently been thrown on the progress and extent of civilization in this area. It is clear now that the country was heavily occupied by agricultural communities in the second half of the third millennium B.C., a period which corresponds with the later phases of the Early Bronze Age in Palestine; the dolmens may belong to this stage. Then comes a long break in the record which extends from the end of the twentieth century B.C. to the beginning of the thirteenth, during which the inhabitants seem to have reverted to nomadism. After this a second great era of sedentary occupation starts, contemporaneous with the Early Iron Age in Palestine: strong fortifications and an extensive exploitation of the copper mines in the south are characteristic of this period: Professor Glueck connects the fortifications with the "fenced cities" which the Israelites found on their way to the promised land, and in the mines he would like to recognize the base of the storied wealth of Solomon; a small site which he excavated near 'Aqaba is identified by him with Ezion-Geber. Another period of great prosperity dates from about the beginning of the Christian era, the period of Petra and the Nabataean kings, who were not only merchant princes but keen agriculturalists, as is shown by their cults and by the numerous traces of dams and irrigation works which are among the most interesting of the new finds; much florid carving was found in a temple called Khirbat Tannur, the one other place where excavation was undertaken. Many of the new sites were obviously watch towers, and their positions throw light on the frontiers of the kingdom and the chief lines of communication; elsewhere Professor Glueck has stressed the part played by the Wadi Sirhan in Nabataean economy.

This book is illustrated with a number of capital photographs, some of the best having been contributed by the Royal Air Force, but the only map is inadequate, few of the sites mentioned in the text being marked; a plan of the Nabataean temple which was excavated is also a desideratum. The writer's discursive style hardly does justice to the wealth of new discoveries which have been made. Students who want to understand the real additions

to our knowledge will have to turn to the special publications listed in the Preface.

The Garstangs' book is far more purely archaeological, a well-illustrated summary of the results of six years' digging at Jericho. The most important finds, scientifically, were those made in the lowest strata, some remarkable moulded figures and rooms with finely plastered floors which date from the Fourth and Third millennia B.C.: the flints and pottery found with them enable these unique finds to be brought into chronological relation with other neolithic and chalcolithic cultures, thus opening a new chapter in prehistory. The larger part of the book however is taken up with the later levels, and a final section by Mr. J. B. E. Garstang is devoted to an ingenious attempt to interpret the remains of one of these, City IV, in the light of the story of Joshua.

It is in this last connection that Professor Garstang's work impinges most closely on Professor Glueck's. The latter's thirteenth-century date for the resettlement of Transjordan can be easily reconciled with the traditional date of the Exodus in the reign of Merneptah; not so Professor Garstang's date for the destruction of City IV at Jericho between 1400 and 1385 B.C., if this is really the city which Joshua destroyed; but is it? Jericho was reoccupied on a modest scale, according to our author, between 1285 and 1100 B.C., and if the traditionalists are right it must have been this settlement which Joshua captured; but this is a question for others to debate. J. W. C.

A HISTORY OF AFGHANISTAN. By Sir PERCY SYKES. *London: Macmillan*, 1940. Two vols. 9×6 *inches;* xiv+411; x+414 *pages; illustrations and maps.* 50*s*

In view of the success of his 'History of Persia,' it was natural that Sir Percy Sykes should turn his attention to the neighbouring country of Afghanistan, which had the additional attraction of being, by reason of its proximity to India, of still greater interest to English readers. Moreover such works on the subject as already existed were inadequate and out of date, and there was not only room for, but an actual need of, a really good work of the kind.

To write such a history is by no means an easy task. The mountainous nature of the country has always placed great obstacles in the path of any attempt to weld the different parts into a coherent whole. Its population, including as it does Persian, Turkish, and Mongolian elements, is far from homogeneous, save in religion; while the great majority do not use the national language (Pashto). For centuries large portions of the present territory were under foreign rule, either Indian or Persian, and it was not until the middle of the eighteenth century that Afghanistan reached anything like the status of an independent kingdom. The author however is not easily daunted, and the difficulties of his task have not prevented him from endeavouring to trace the course of events in this region from the earliest times. For a long period the materials are scanty; and a large portion of the first volume assumes the character of a general history of south-western Asia, in which Afghanistan makes rather infrequent appearances. Firmer ground is reached with the establishment in 1747 of the Sadozai dynasty under the celebrated Ahmad Khan, who not only extended his rule over the whole of the country but for a time dominated the Punjab, Baluchistan, and Sind. The downfall of the dynasty in 1818 was followed by the break-up of the empire, but eight years later Dost Muhammad succeeded in making himself the ruler of Kabul and Ghazni. The interest of the story quickens when, a little more than a century ago, the British began to take a hand in Afghan politics, prompted thereto by fears of Russian aggression. The story is melancholy reading, and need not be

recapitulated here. Matters improved in 1880, when there emerged a strong Amir, in the person of Abdur Rahman, whose wise administration did much to consolidate his unruly kingdom. His son, Habibulla, followed in his father's footsteps. During the Great War he managed, though with some difficulty, to keep his country neutral; and his assassination, early in 1919, was an untoward event. He was succeeded by his third son, Amanulla Khan, who, finding his position insecure, sought popularity by declaring war against the British. His forces were soon driven back across the frontier, and he found himself compelled to sue for peace. The terms granted were unexpectedly lenient. Russian power had ceased to be a menace, and the British Government agreed to regard Afghanistan in future as completely independent. This led to the establishment of an Afghan legation in London and of a British legation in Kabul. It may be added that our continental rivals did not fail to take advantage of the new situation.

King Amanulla in 1928 paid a visit to various European countries, including England, where he was received with much cordiality. On his return, impressed by the measures taken in Turkey and Iran to adopt western customs, he instituted a series of reforms which proved intensely distasteful to his subjects. A revolt ensued; Amanulla was forced to abdicate, and after a time he retired to Europe. A period of confusion followed, and then in the autumn of 1929 Nadir Khan, a former commander-in-chief, ascended the throne, and for four years he governed wisely and well. His assassination by some of his servants led to the accession of his son, Zahir Shah, who is still the reigning monarch. Under his administration the country has made slow but steady progress and has materially improved its economic position.

All this is told clearly and impartially, and the narrative is interspersed with many shrewd comments and notes based upon the writer's personal experiences. Its value is enhanced by the fact that many of the later chapters have been submitted to, or discussed with, officials who played leading parts in the events described. W. F.

AFRICA

THE PREHISTORY OF UGANDA PROTECTORATE. By T. P. O'Brien, with a chapter on the Pleistocene Succession by J. D. Solomon, and an appendix on the Mammalian Fossils by A. Tindell Hopwood. *Cambridge: University Press*, 1939. 10×7½ *inches;* xii+320 *pages; illustrations, map, and figures.* 25*s*

This embodies the results obtained by the rather ambitiously named African Prehistoric Research Expedition in the course of an eighteen-months campaign in Uganda. The work of the expedition was carried out by Mr. and Mrs. T. P. O'Brien, with the collaboration for a shorter time of Dr. J. D. Solomon, who contributes a chapter on the Pleistocene Succession. The essential spade work in the archaeology and Pleistocene geology of this region had, of course, already been carried out by Mr. E. J. Wayland, in the course of fifteen years' work as Director of the Geological Survey; the efforts of O'Brien and Solomon have not therefore the same pioneer character as those of Leakey in the adjoining Kenya field. It may be said at once that their conclusions differ from those of their predecessor in many important respects, but it is very difficult to estimate the true value of their work until we have before us the monograph, now in preparation, which will present the full results of Wayland's more detailed researches and incomparable knowledge of the country.

The first point on which the authors part company with Wayland is a funda-

mental one—nothing less than the whole question of the interpretation of the Pleistocene geology of Uganda. Solomon discards more or less completely the Pluvial Hypothesis which has for so long held the field in East African prehistory. In its place he postulates regional earth movements which in the course of the Pleistocene produced a double tilt, from north-east to south-west and back, of the country lying between the Albertine Rift and Lake Victoria. In this way he explains the reversal of flow which is visible in certain river valleys of this area, and which Wayland attributes to changes in lake levels caused by major variations in rainfall. The scrapping of the Pluvial Hypothesis is a revolutionary change in the approach to East African prehistory, and even if one feels that this hypothesis has perhaps been taken too much for granted in the past, its abandonment seems to call for a more detailed statement of evidence and fuller discussion than is given it by Dr. Solomon.

The geological evidence is to a certain extent repeated in succeeding chapters by O'Brien, who criticizes some of Solomon's conclusions on minor points. O'Brien however is primarily an archaeologist, and his pronouncements on geology must necessarily be treated with reserve. A more satisfactory result might have been obtained by a full collaboration between geologist and archaeologist in the authorship of the book as a whole—a partnership, for example, such as that exemplified in the work of Miss Gardner and Miss Caton Thompson, in which each contributes her special knowledge without undue excursion into the field of the other, the result being presented as a unified whole.

O'Brien is on firmer ground in dealing with archaeological questions, and his general remarks on the typology of stone implements are pertinent, and show both knowledge and common sense. When he comes to the detailed consideration of his Uganda material however his treatment is in places rather slight, and gives a certain impression of haste. The most original and most interesting feature of this part of the book is his description of the Tumbian culture, and his discussion of its origin. As in geology, so in archaeology, there is a marked divergence from the findings of Wayland, but it will be possible to judge its value only when we have the full evidence before us. Incidentally, nowhere in the book can one find an exact statement of the places visited and the excavations made, nor is there an inventory to give a clear idea of the number of specimens on which the study of each group of implements is based. This omission unfortunately is only too common in expedition reports.

The book is admirably produced, with first-rate illustrations, but it is possible to question whether the amount of matter which it contains completely justifies publication in the form of a monograph. With some slight economies of presentation (*e.g.* the print is large, and many implements are figured twice, in photographs and line-drawings) it could quite easily have appeared as a fairly long article in a scientific journal, and this would perhaps better have fitted its provisional status while awaiting the fuller study promised by Wayland in collaboration with Van Riet Lowe. D. A. E. G.

GENERAL

THE OBSERVER'S BOOK ON ASTRO-NAVIGATION. Parts I and II. By FRANCIS CHICHESTER. *London: George Allen and Unwin*, 1940. $7 \times 4^{1}_{2}$ *inches;* 103 *pages;* 83 *pages; diagrams.* 2*s* 6*d each*

The object of these books is to teach enough navigation by sun and moon, planets and stars, for position fixing in the air, with a bubble-sextant, the Air Almanac, and the British astro-navigation tables recently calculated by the

Nautical Almanac Office under the direction of the Astronomer Royal, who at the Afternoon Meeting of the Society on 14 March 1938 opened a discussion on the new form of Nautical Almanac for rapid position-finding. To that discussion we may refer students for an admirable exposition of the principles involved (*Geogr. J.* 92 (1938) 133–48).

Mr. Chichester's aim is to enable an intelligent man to teach himself air-navigation, or to provide in the book a brief refresher course for one who has already learned it but not recently practised it. These alternatives are not easily achieved in a single book. The beginner may very well find it advantageous to have everything said at least twice in slightly different language, and each step of the process frequently reviewed: the man who knows the principles but wishes to refresh himself on details may find the explanation rather long, and wish that Part I contained a few worked examples arranged on the standard forms, to accompany the explanation. But for the beginner who wishes to understand why everything is done, and not merely how to do it, the plan of the book is well conceived. It is pleasantly written, accurately phrased, and printed in elegant Baskerville type. It reproduces pages from the Air Almanac for 1940, considerably improved from those given by the Astronomer Royal for 1938. The numerous figures are clearly if not finely drawn; the worked examples are relegated to the end of Part II. But the author is tied to the terminology and nomenclature of the Air Almanac, which was, in the opinion of the reviewer, not well enough considered.

The essence of astro-navigation is that for the instant of observation one calculates from the Air Almanac, with the aid of auxiliary tables, the point on the Earth where the sun, moon, planet, or star is in the zenith, and what is its bearing; from the observation of the star's altitude one derives at once the radius of a circle around that sub-stellar point, upon which the observer must be. The star is in effect referred from the celestial to the terrestrial sphere, and the device which has so greatly simplified astro-navigation is to tabulate in the A.A. for conveniently short intervals of time the Greenwich Hour Angle of the sun, moon, or planet, and a ready means of calculating the G.H.A. for any one of fifty chosen stars. The celestial co-ordinates of the stars are tabulated in the accustomed Declination and the unfamiliar "Sidereal Hour Angle," which is 360°—the Right Ascension. It has always seemed to us that the idea of Hour Angles belongs essentially to the terrestrial meridian, and that Sidereal Hour Angle is a contradiction in terms. The French call it *Ascension verse*. We want a neat British equivalent to denote 360°—R.A.

To find the G.H.A. of the star we must tabulate in addition the G.H.A. of the zero celestial meridian from which S.H.A. is measured: and this has the cumbrous name G.H.A. First Point of Aries, or G.H.A. followed by the symbol for Aries, which is not cut in the best founts of type, as may be seen in the Air Almanac and in Mr. Chichester's book. If there was no convenient portmanteau word to be found for "360°—R.A." and for "G.H.A. Aries," it might have been much better to invent new symbols than to tie oneself to one term which is doubtfully correct and one which is hopelessly cumbrous and inconvenient; or perhaps to use R.R.A. (Reversed Right Ascension) and G.H.A.Z. (Greenwich Hour Angle of Zero), which are no longer than the initials now in use, and may be considered more appropriate. Of the bogus names allotted to some of the stars it is better to say nothing more than was said three years ago.

Part II of Mr. Chichester's book contains a good account of the Bubble Sextant Mark IX, designed by Mr. P. F. Everitt, of Henry Hughes and Son, Ltd., which is the present standard instrument. By an ingenious recording mechanism it adds up and takes the mean of a set of six consecutive sights,

relieving the observer of much arithmetic, and to a great extent eliminating by this repetition the errors due to bubble displacement by casual accelerations of the machine in bumpy air. Three sets of six settings can be taken with the Mark IX sextant within two minutes, but only when the observer has learned to do the complicated drill automatically. There are excellent drawings of the construction, with careful explanation of every ingenuity in the design, but until one can read this part of the book with the instrument in hand it is difficult to appreciate the full merits of Mr. Chichester's exposition.

The combination of new Air Almanac and Mark IX sextant is designed above all for speed at the expense of unnecessary precision. We had hoped to try how the new ideas can be applied by travellers on land, with more leisure but desiring a little more precision. Unhappily the simpler bubble-sextant which the Society purchased is a casualty of the war, together with the Fellow who was trying it at sea. But there can be no doubt that the bubble-sextant and Air Almanac would be just the thing for navigating a car on a long desert raid.

A. R. H.

THE MONTHLY RECORD

MEDALS AND AWARDS 1941

His Majesty the King has approved the award of the Royal Medals as follows: the *Founder's Medal* to Major P. A. Clayton, D.S.O., for his surveys in the Libyan Desert and his application of this experience to desert warfare during recent operations; and the *Patron's Medal* to Dr. Isaiah Bowman, President of Johns Hopkins University, Baltimore, for his travels in South America and for his great services to the science of geography while Director of the American Geographical Society of New York.

The Council have awarded the *Murchison Grant* to Mr. C. T. Madigan, for his explorations and research in Central Australia; the *Back Grant* to Mr. Alfred Stephenson, for his surveys in South-East Graham Land; the *Cuthbert Peek Grant* to Mr. Marcel Aurousseau, for his valuable services as Secretary of the Permanent Committee on Geographical Names; and the *Gill Memorial* to Captain F. Spencer Chapman, Seaforth Highlanders, for his exploration of high peaks in Sikkim and Tibet.

LAND AND POPULATION OF YUGOSLAVIA

The *Geografski Vestnik*, the bulletin of the Geographical Society of Ljubljana for 1940, contains four articles on the cultivated area, and growth, distribution, and density of the population of Yugoslavia. These articles are in Slovene, and the following note is based upon the French résumés accompanying them.

In conformity with the physical configuration, the highest proportion of cultivated land (including arable, vineyards, and orchards) to total area is in the north-east of the kingdom. In the northern and eastern Vojvodina, the plain of Srem, and the valley of the lower Morava, the cultivated land is 75 per cent. or more, and the greater part of the area with 40–75 per cent. cultivated is adjacent to this; included here are the Drava basin from Slovenia to the southern Vojvodina, areas south of the Sava and in northern Serbia, the valley of the Morava to Leskovac, and the valley of the Nišava to Caribrod. The only other areas of similar intensity of cultivation, the result of recent colonization, are in southern Serbia, for example around Kumanovo, Preševo, and Kratovo. The vineyards on the tertiary hills of north-west Croatia, Slavonia, and Bosnia, occupy 25–40 per cent. of the surface. The lowest figures for cultivated area are found in the Dinaric mountains, particularly in Crna Gora (Montenegro), and in the north-west Alpine zone, where it is less than 5 per cent.; other karst regions have a slightly higher proportion, up to 20 per cent. Corresponding very closely with this distribution is the relation between cultivated land and meadow plus pasture land, the zones with a high proportion of arable land to pasture lying in the areas of intensive cultivation. Thus in the northern Vojvodina around Bačka Topola 97 per cent. of the farm land is arable. The central zone of the country, running through Slovenia, upper Croatia, and Bosnia, has less than 50 per cent. of farm land in pasture. In the pastoral regions of the Mediterranean karst, Hercegovina, and southern Serbia, the lowest proportion of cultivated land is in the Kolašin district of the former Montenegro, 3·3 per cent.

The highest density of population per square kilometre of the total area is not, as might perhaps be expected, on the north-eastern lowlands in the Danube and tributary valleys, but on the vineclad hills of Hrvatsko Zagorje and the

neighbouring plains (125–150 per square kilometre). Northern Serbia, the basin of the lower Morava, has densities ranging from 100 to 120. Slightly lower densities (75–100) prevail in parts of the Danubian lowlands, *e.g.* the district of Bačka, the sub-Pannonian foothills, and the middle valley of the Morava up to Vranje. Another region of relatively high density lies on the Adriatic litoral around Sušak. The categories below 75 per square kilometre are distributed over the country according to local conditions, and in some cases, to political events. Thus in the infertile karst regions and politically unstable areas in southern Serbia, the density falls to less than 25.

The last article to be noted deals with the growth of the population from 1880 to 1931, excluding south Serbia and Montenegro, for which reliable figures are not available. For comparison it may be noted that in this period the population of England and Wales increased by about 54 per cent. The population of Yugoslavia increased 55·7 per cent. in this period, but there were wide local differences. The average annual excess of births over deaths, for example, varied from the high figure of twenty per thousand in former Bosnia-Hercegovina to five per thousand in the Vojvodina. There is no indication however of the extent to which these variations were the result of differences in the death-rate. The influence of migration also varied from region to region: emigration was particularly heavy from the karst regions of the north-west, and areas of immigration included the Vojvodina and parts of Croatia and of southern Serbia. The greatest percentage increase was in the former Bosnia and Hercegovina, where the average was 85, but in the north and east, and around Mostar, it was as much as 100. This was due largely to the exceptionally high birth-rate. Up to the year 1910, in northern Serbia, approximately the former kingdom, the growth was at about the same rate. For the whole period this was 71, but as a result of the wars between 1910 and 1921, 10·8 per cent. of the population was lost. This loss particularly affected the central Šumadija, south of Beograd. Large increases were registered in the basin of Toplica and Kruševac. North-eastern Serbia has always been thinly populated, and this tendency has been accentuated since 1910, largely through endemic disease. Croatia-Slavonia showed a total increase of 52·8, but in certain areas, for example the mountains of Požega, where the oak forests are being exploited by immigrant settlers, it rose to 100 per cent. The areas of lowest increase here are the upper Croatian karst and the Croatian littoral, which despite a high birth-rate are declining in population, especially since 1910. Dalmatia showed a total increase of 47·9 per cent., though in the southern half and in most of the islands there was little or no growth. In the Vojvodina—the Banat, Bačka, and Baranja—areas of relatively dense population and a high proportion of arable land, the growth was only 33·9 per cent., a very low birth-rate being made up by immigration. Slovenia was the region with the lowest increase of all, 19·7 per cent.; the alpine and karst mountains have always been a region of emigration, since 1918 to the industrial areas of Europe and other parts of Yugoslavia, and the natural increase, resulting from a relatively high standard of life, has been low.

THE ZANZIBAR MUSEUM

The work of the Peace Memorial Museum, Zanzibar, is illustrated by photographs and comments by the Curator, Miss A. Nicol Smith, in the *Museums Journal* for March. Described in a report to the Carnegie Corporation as one of the best educational museums seen in a tour of Africa, it was built by public subscription and a government grant in 1925. In opening it, H.H. the Sultan of Zanzibar called it "Beit-el-Amani," or House of Peace. This institution is designed as a general regional museum for the education of the local people.

The Museum Committee is also charged with the care of archaeological remains in the Protectorate. Visual information is presented on a number of subjects, particularly health and hygiene, and films are shown. One bay illustrates mosquitoes, their breeding places, and remedial measures. There are also important historical collections, and a small reference library. The Swahili attendants assist in preparing natural history specimens and making models. A grant was received from the Carnegie Corporation in 1935, and it is hoped that with the return of normal conditions it will be possible to extend its work. A museum of this type is particularly valuable among simpler, partially literate, communities; it stimulates interest in their surroundings, and demonstrates, by preserving records of the past, that their cultural achievements and development are appreciated.

JOURNEY IN SOUTHERN TIBET

A brief note on a journey in Southern Tibet was published by Giuseppe Tucci in the *Bolletino* of the Italian Geographical Society for February 1940. Its purpose was mainly archaeological and historical, particularly to examine the monuments and manuscripts of the early Buddhist period and their relations to the art of neighbouring countries. The writer, accompanied by his wife and Captain Boffa, left Gangtok in April 1939, crossing the Kongra La to Kampa Dzong and Sakija, the infrequently visited monastery which was a centre of Tibetan culture from the thirteenth to fifteenth centuries. From Sakija the party travelled down to the Tsangpo at Lhatse, examining on the way the great thirteenth-century stupa at Ghian, and then turned eastwards through Pindzoling and Tashi Lhunpo to Shigatse. The Tibetans generally traverse this stage by raft down the Tsangpo in three days, half the caravan time. The ancient monastery of Pindzoling is mostly in ruins, but the stupa with old and important frescoes still stands. At this point the route leaves the river bank for narrow valleys and passes to Tashi Lhunpo. The most interesting place on this stage was Netang, the largest printing establishment in central Tibet, where the great Buddhist collections are printed in Tibetan. A short march beyond is Tashi Lhunpo, the great monastic settlement of six thousand monks, and Shigatse, the centre for Tibetan–Nepalese trade. After visiting several monasteries in the neighbourhood, including Ngor with its collections of Sanskrit manuscripts, and Shalu, where there are thirteenth-century frescoes of Chinese influence, the party took the trade route through Gyantse, and returned to India at the end of September. The results of the expedition, particularly the hundred Sanskrit manuscripts discovered, are said to make possible a definitive study of the religious and artistic history of the region. The itineraries also permit the amplification of the maps of this imperfectly known area, though no regular survey was carried out by the party.

JAMAICA

As far as is practicable in present conditions, much is being done to carry out the recommendations of the West India Royal Commission, 1938–39 (Cmd. 6174, 1940). A Comptroller for Development and Welfare and an Inspector-General of Agriculture have been appointed, and imperial funds will be available for urgent development schemes, but the full working of the West Indian Welfare Fund, to receive one million pounds a year for long term social, public health, and labour reform, is necessarily postponed. It was also announced in Parliament on March 12 that H.M. Government would recommend certain constitutional changes in Jamaica. These would include universal adult suffrage, an enlarged Legislative Council, to comprise approximately double the present

number of elected members, and a reduction of the number of official members. As these changes could not take place without reliable population statistics, and with the present standard of local government, the Governor had been requested to take a census and to reorganize local government. This step also follows closely the Royal Commission's recommendations on constitutional reform.

The Commission also made detailed recommendations on the improvement of the economic and social structure of the island. The carrying out of these has also been modified by present conditions, and before referring to them, some account of recent trends may be of interest. The position before the outbreak of war is given in the Colonial Report for 1938, which contains the latest detailed figures available. One factor in the island's condition, frequently emphasized by the Commission, is the high density of population. In 1938 the population was estimated to be 1,173,645, an average density of 260 per square mile, without deducting considerable areas of forest and swamp: about one-third of the land accounted for in tax returns is under cultivated crops. Added to this is a high rate of natural increase, and in recent years the former considerable outward migration has been replaced by an inward movement, the net inward balance in 1938 being twelve hundred persons. As there are no mineral deposits of importance, the people are dependent upon agriculture for their livelihood. This is reflected in the exports, which were just over £5 million in 1938, the highest on record, approximately £4 6*s* per head. The largest single items were bananas (£2·9 million), and sugar and rum (£1·1 million). Imports amounted to £6·49 million (£5 10*s* 6*d* per head). Towards this unfavourable balance of £1·45 million, partly due to heavy imports of sugar machinery, the tourist traffic is thought to contribute £0·4 million, and external investments, the services of Jamaican vessels, and remittances from emigrants the remainder, though the exact composition of these invisible imports is uncertain. It is however the character of the imports which has attracted criticism, for food, principally rice and wheat, condensed milk, and tobacco account for about a quarter. It is at first sight strange that an island should import fish to the value of £0·20 million a year, and that an agricultural community should be so dependent upon food imports, but the preference of the peasants for cash crops is a legacy of the plantation era. The former item is due to the lack of up-to-date organization and appliances for dealing with the local catch. No figures are available for domestic production or consumption, but the standard of living is indicated by the public revenues. The receipts in 1938 were approximately £2 per head, expenditure was slightly less, while the public debt was about £4 per head. Of the expenditure, about 30 per cent. was allotted to social welfare and economic development.

The problem of economic advance for Jamaica is therefore concerned with increasing the income from products which meet with strong competition in the world market, rendering the island more self-sufficing in food supplies, and securing a better distribution of the population on the available land, and a higher return for the labour expended. The Royal Commission considered that all sections of West Indian opinion should be fully aware of the profound influence of the rapid growth of population on the various social and economic problems of the islands. To absorb this growth it is essential to "secure an intensification of the agricultural system through a re-orientation in the direction of mixed farming with far greater home production of essential food-stuffs," and to improve the position of the agricultural exporting companies. This development requires the abandonment of shifting cultivation by peasant farmers, and of the continuous growing of single crops by the larger estates. The Commission's recommendations were mainly concerned with improving the collection and organization of knowledge necessary for this to be successfully achieved,

e.g. by carrying out topographical and soil surveys, and by research into agricultural systems and marketing conditions. When the standard of husbandry has thus been raised, existing land settlements should be improved and new ones established, the government taking compulsory powers of acquisition, and providing credit facilities at the beginning. The Commission did not propose that government should finance industrial enterprises in general, but thought it might foster certain projects such as a cement works or the local manufacture of coconut products.

To some extent war conditions have promoted progress in the directions desired by the Commission, though fresh problems have also arisen. According to details published in recent numbers of the *Crown Colonist* imports for 1939 at £6·51 million were the highest since 1929, but exports declined to £4·75 million, and this tendency continued into 1940, exports in the first nine months being down by £1·57 million on the same period for 1939. This was largely due to a scarcity of bananas owing to widespread destruction by hurricanes in 1939. The British Government have aided producers by buying the current crop, and efforts are being made to increase exports to Canada and the United States. The entire sugar crop has also been taken by Britain; production is increasing, and the output estimated for 1941 is 148,000 tons. The government is seeking to limit the importation of food-stuffs and manufactured goods by stimulating agriculture and domestic industries. The plantations are putting a larger area under food crops: a corn mill has been established, corn growers given a guaranteed price, and foreign imports of corn prohibited. The growing of fresh vegetables, potatoes, etc., and the improvement of live stock is being encouraged. The Land Settlement Department's work is also expanding: there are now over twelve thousand allotments on land settlement properties, and the department is administering 250,000 acres of Crown lands. As a result of the policy of assisting home industry, factories for condensed milk, matches, chemicals, and cement have been established, though not yet capable of meeting the whole demand. After declining very rapidly the tourist industry is now stated to be recovering satisfactorily. A number of skilled workmen have found employment on the Panama Canal, and it is expected that the building of the United States' leased base at Kingston will provide work for many, and presumably bring much money into the island.

THE GREAT BARRIER REEF COMMITTEE

We have received a copy of the minutes of a meeting of the Great Barrier Reef Committee, held on November 27, in Brisbane. In spite of the war, research work, although on a smaller scale than usual, and a careful watch over the fauna and flora are being maintained. Dr. Dorothy Hill has been appointed to carry out research work in the Moreton Bay area, where desert sand forms, coral reefs, and the local geology are being investigated, work unfortunately restricted by lack of petrol. In October the Fahnestock Expedition from the American Museum of Natural History arrived to study and collect specimens of the bird life of the south-western Pacific and mount a Great Barrier Reef habitat group. Unfortunately *Director II*, the expedition's yacht, struck a reef and sank, but much of their equipment was saved, and owing to the hospitality of the Great Barrier Reef Committee the expedition was able to complete its work.

The meeting discussed reports of damage to coral and other fauna on those reefs accessible to tourists; on the recommendation of a special sub-committee it was resolved to report that the "Orders in Council, which prohibits the taking of coral from certain islands met the needs of the situation so long as these

regulations were strictly adhered to and that the Council did not think it desirable to interfere with a reasonable trade in marine products or the natural desire of tourists for souvenirs or curios." Many islands have been proclaimed national parks: Corroboree Island, Pelican Island, Divided Island, and Sloping Island, and more than fourteen others. The Financial Statement showed a substantial balance in hand for further work.

THE COMMONWEALTH MAP OF ANTARCTICA

In our review of this map in the *Journal* for December last we omitted to state the price, and how it may be bought: this information was given in a leaflet which came with it.

The map is issued in two sizes. The two sheet map, 60×40 ins., costs 7*s* 6*d*; the one sheet map, 30×40 ins., costs 5*s*. These prices include the Handbook and Index, which are not sold separately. Copies may be obtained from the Australian High Commissioner, Australia House, London W.C.2, and from the Australian Government Trade Commissioner, 630 Fifth Avenue, New York.

A GLOSSARY FOR THE GREAT SOVIET ATLAS

For those who do not read Russian easily the length of the titles to the maps, and the elaborate keys to the many symbols used upon them, presented difficulties not easily solved. It was therefore an excellent idea of the Department of Geology and Geography of Syracuse University, N.Y., to make and put on sale a translation of the titles and sub-titles which runs to more than a hundred "planographed" pages of typescript: translated by Andrew Perejda and Vera Washburne under the direction of George B. Cressey. The copy of this Glossary, which the Society recently purchased, has been studied lately by Professor E. H. Minns of Cambridge, who has found that the accuracy of the translation is not all that we had hoped, and has kindly provided a long list of emendations, which will be entered in the copy which is kept in the Map Room of the Society with its copy of the Atlas, and may be consulted there.

The errors are of several kinds. Some can be corrected at sight: The monk *Beatty*, A.D. 776 (Plate 4–5); the *zebra*, for jerboa, on the Siberian steppe; and many names of rivers left in their adjectival form, as *Kurinsk*, *Rionsk* for Kura, Rion (101). Others are not so easy: *porous* should be alkaline, and *original* should be basic (94–5); *Hertzian* for Hercynian (90), *ox* for wolf (125), *Areas arid to the Revolution* for Areas drained before the Revolution, *Milk sheep* for milk and vegetables (161), and *steam rising* for ploughing up fallow (161) are certain mistranslations; and it is believed that *Anthracite* should read Oil-shale (129–30), *Petroleum and by-products* means Pipe lines and conveyors (132), and *Butter* should be Oilmills (144). There are mistakes in simple geographical terms: *Straits* for peninsula and *Levees* for Areas liable to flood. *Market for muskrat* should read Place where muskrat has been turned out (126); and *Cotton paper* is a mistranslation of two words meaning Cotton (no paper), carefully constructed to avoid the difficulty that *bumaza* means both cotton and paper (141–2). These are some of the errors which Professor Minns finds in his study of Part II, and he has left unresolved the legend for Plate 125B, showing the Autumnal migration of birds including *Various other snipes and sparrows* and *Mud game*, the *Skater*, *Forest horse*, and *Double snipe*, which have a look of being wrong.

The full descriptions of the projection of each map are generally translated adequately, but the Gall's Cylindrical Stereographic Projection, *parallels unequal beyond* 30° means literally something like Parallels cutting at 30°, or Standard

parallel 30°; and in Plate 1–2–3, *Scale by inclination* should be Scale along the meridian, or Scale of latitude.

The difficulties for English-speaking people of using this remarkable Atlas are thus not altogether solved by the enterprise of Syracuse University, and we shall be glad to receive from students with a good knowledge of technical Russian any further suggestions for the translation of the technical terms which abound in it.

ON DATES IN THE LOG OF THE *HERO*

In his paper in the *Geographical Review* for October 1940, Colonel Lawrence Martin reproduces a page from the log of the *Hero* dated Friday November 17, and prints a transcript thus:

Friday November 17th

> These 24 hours commences with fresh Breeses . . . at 12 [midnight on the Calendar day of November 17] hove Too under the Jib . . . at 4 A M [on the calendar day of November 18, 1820] made sail in shore and discovered—a strait . . .

The passages in square brackets are his interpretation of the date.

In my paper on the Log of the *Hero*, in the *Journal* for December 1940, I followed Colonel Martin's interpretation, which assumes that Palmer in the *Hero* kept astronomical time, the twenty-four hours of November 17 beginning at noon of that civil date. It seemed so natural that a seaman who used the Nautical Almanac should keep the time of that almanac, that I forgot it was well established that at the beginning of the nineteenth century he did not, at least in the British service.

In a letter of February last Lieutenant-Commander Gould suggested that Colonel Martin and I had both been wrong in our dealing with Palmer's dates, and it seems likely that he is right.

The question of Nautical Time and Civil Date was discussed in a note published in the *Journal* for August 1935, vol. 86. 153–7. Until 1805 there were three times in use in the British Navy: nautical, civil, and astronomical. The nautical day began at noon, twelve hours earlier than the civil day; thus the details of the battle of Trafalgar are shown in the logs under 22nd October p.m., which is the afternoon of the 21st. Nelson's private diary was kept in civil time. In working up a sight the navigator must have used astronomical time and date, a day different from the ship's nautical time; but this never appeared in the log.

On 11 October 1805 the Admiralty ordered that in logs of H.M. ships "the calendar or civil day is to be made use of, beginning at midnight"; but the order did not reach the Mediterranean Fleet until after Trafalgar. All this is carefully set out in the Report of the Admiralty Trafalgar Committee (1913).

So after 1805 the nautical day was not used in the British Navy, but Commander Gould believes that it remained in use in British and other merchant ships until much later, and argues that so long as the log was kept from noon to noon, it was kept in nautical and not astronomical time. The custom was not so illogical as it appears at first sight of the fair log, because it was the practice to keep rough entries on the log-board and write them all up at noon. The date of the log page for each day is the date of the noon at which the log was written up; thus the noon of November 17 in the log of the *Hero* would be not the noon on which "these 24 hours commences" but the end of them. And Palmer's sight of land at 4 a.m. would be on November 17, not 18.

The matter is curious but of small importance in Antarctic history. Bransfield when he discovered land on 30 January 1820 would have been keeping

civil date, in obedience to Admiralty Order of 1805. Whether Palmer discovered his land on the early morning of November 18 or 17 in the same year matters little for the main question; but it would be interesting to have the detail correct, and we should be glad to know what is the evidence for American practice at the time. A. R. H.

MEETINGS: SESSION 1940–41

Sixteenth Meeting, 3 March 1941. Mr. Leonard Brooks, Vice-President, in the Chair

Elections: D. Nandan Arora, M.A.; H. L. Clegg, B.SC.; Major R. Delacombe, M.B.E.; Captain R. M. Gimson; R. J. Waite; F. W. Winyard

Paper: The fifth commission of the R.R.S. *Discovery II*. By Dr. N. A. Mackintosh

Seventeenth Meeting, 10 March 1941

Paper: The structure of a temperate glacier. By Mr. Gerald Seligman

Eighteenth Meeting, 17 March 1941. The President in the Chair

Elections: F. C. Couzens; S. May, B.SC.; Mrs. MacDonald White

Paper: Crossing Baffin Land. By Captain Graham Rowley

Nineteenth Meeting, 24 March 1941. Geographical Films: Hadhramaut (colour) and Somaliland. By Mr. A. Beeby Thompson

Twentieth Meeting, 31 March 1941. The President in the Chair

Elections: L. K. Darbyshire; G. L. A. Dunphy; G. May

Paper: Railways of the Balkan Peninsula. By Mr. S. H. Beaver